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Scientific, Technical and Economic Committee for Fisheries (STECF)
Report of the SGMOS-10-03 Working Group

Development of the Ecosystem Approach to Fisheries Management (EAFM) in European seas

6 - 10 September 2010, RENNES, FRANCE

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STECF UNDERTOOK THE REVIEW DURING THE PLENARY MEETING HELD IN BRUSSELS ON NOVEMBER 8-12 2010

1. BACKGROUND

The SGMOS 10-03 working was set up in line with the recommendations of the STECF 30th plenary meting regarding the improvement of the ecosystem approach to fisheries management and the development of bio-economic modelling (PLEN-09-01). In this report STECF note: "One of the main and explicit objectives of the ecosystem based approach to fisheries management, as defined under Council regulation (2371-2002), is to optimise economic activity while seeking to minimize the impact on the relevant ecosystem (i.e. damages on habitats or reduction in stock abundance, etc). […] The scale taken into account is crucial and should be relevant for the management purposes. Currently, biological and economic data are available at different scales. STECF suggests that the principle scale of analysis should be the ecosystem and data should be (dis)aggregated accordingly. […] STECF considers it to be an urgent and prior task to setup the organizational structure for addressing future ecosystem analyses. An initial step should be to convene a working group under the auspices of STECF-SGMOS to define a general analytical framework, data availability and illustrate this on some case studies".

Thus, the overall aim of the SGMOS 10-03 working group was to provide a pragmatic example of a first attempt assessment and advice in support of EAFM. It achieved this by i. utilising long time-series of catch and various stock assessment metrics, including the analysis of ecosystem indicators, ii. an analysis of the characterisation of fleet impacts, iii. an analysis of economic performance, iv. an assessment of operational status of ecosystem models to support EAFM.

Based on this first attempt, the working was also requested to provide comments and suggestions regarding the best way to improve EAFM in European waters. It especially achieved this by i. suggesting a reference list of ecosystems submitted for consultation with various bodies, ii. recommending a two steps procedure to implement operational advice-oriented ecosystem and bio-economic models in European marine ecosystems, iii. suggesting to engage discussions with other STECF groups and with ICES in order to promote an advice-oriented ecosystem approach in various existing committees.

2. TERMS OF REFERENCE

STECF is requested to review the report of the STECF Working Group meeting, evaluate the findings and make any appropriate comments and recommendations.

3. STECF COMMENTS AND RECOMMANDATIONS

Comments on the approach developed by the SGMOS 10-03 working group

It is clear that considerable effort has been applied in preparing the STECF-SGMOS 10-03 WG report and the WG is to be commended on the quality and quantity of analyses undertaken. Overall, the conclusions reached by the Working Group are supported by the STECF. Additional specific STECF comments are given below:

In relation to the methods used, the working group itself acknowledges that its work was a very first step, notably limited by the availability of data. The WG made some useful suggestions to improve the methodology (see section 5.1 of the report). STECF agrees with these suggestions and adds the following comments:

- Graphs related to the synthesis on stocks status, stocks mean trajectories or sustainability index of fleet segments are very useful but should be interpreted with great care. On one hand, using $F_{0.1}$ as a proxy for F_{msy} should be considered as a transitory step until reliable estimates of F_{msy} are available. On the other hand, "painting in green" the most precautionary part of such graphs may induce the idea that the green area ($F<_{F0.1}$ and $B>_{B0.1}$) is recognized as the common target of fisheries management for all stocks. This is currently not the case. F_{msy} forms a target not a lower bound on exploitation. Where biomass targets are used they are often PA values such as B_{pa}, not the much higher value of $B_{0.1}$. Some thought needs to be given to the representation of targets in such diagrams.
- To supplement the above approach, there is a need to integrate a much wider range of information into a qualitative model (integrating environment, economic and biological variables) to assess the ecosystem risks associated with increasing or maintaining present fishing effort. One such approach has been described by Caddy (1998).
- STECF notes that the fleet-based approach developed by the working group is workable and a useful way to show the dependency of the fishing fleet on certain stocks and ecosystems. Further elaboration of the adopted approach in the future, may allow STECF to add fleet economic performance to the stock advice.

In general, the analyses performed by the SGMOS 10-03 WG were somewhat constrained by the TORs of the WG, which did not relate to aspects of the Marine Strategy Directive Framework (MSFD). This is especially the case regarding ecosystem indicators. The working group was only requested to calculate (or to gather results for) indicators from the reference list defined under the umbrella of SGECA and endorse at the 09-01 plenary meeting of STECF. With the benefit of hindsight, it may have proven useful if STECF had included reference to indicators in relation to the MSFD and the overall assessment of the Good Environmental Status (GES).

Then, STECF considers that the methodology utilised by the working group is limited by the specification of data in the DCF. In particular, the list of ecosystem indicators required to assess the ecosystem impact of fishing should not be limited by the availability of data coming from the DCF (further elaboration is given below under "*a reference list of European marine ecosystem"* in relation to the MSFD). This also relates to economic indicators and cost/benefits analyses which also should not be restricted to what is recorded by DCF. STECF notes that in order to achieve such an ecosystem-based approach a further improvement in the data collection is necessary. In particular, the fishing fleet data must be collected on a more disaggregated level between areas (see below). As for ecosystem indicators, appropriateness of data collected within the DCF should probably be revisited in the light of the MSFD.

It is notable that the list of ecosystem indicators developed by the STECF outlined by the Commission in 2008[1] and used by the SGMOS working group does not include any abiotic components such as temperature (SST) and nutrients and the biotic variables are limited to the fish stocks alone. The inclusion of a wider range of abiotic and biotic variables would allow the effects of a changing environment to be taken into account, particularly in relation to assessing likely favourable/unfavourable conditions for recruitment. Most (if not all) of the present ecosystem indicators are reactive. In addition, "*STECF notes that the DG-Mare interpretation of the Ecosystem Approach to Fisheries Management (EAFM) is as follows: "the approach that strives to balance diverse social objectives, by taking into account knowledge and uncertainty about biotic, abiotic, and human components of ecosystems and their interactions and applying an integrated approach to fisheries within ecologically meaningful boundaries" (EC, 2008 SEC(2008) 449)*".

It is also important to recognise that there are other approaches being developed to deliver an EAFM, notably those by NOAA (USA) & DFO (Canada), which may ultimately have greater utility in delivering an EAFM.

STECF comments on the recommendation from the SGMOS 10-03 working group

. Defining a reference list of European marine ecosystem

The SGMOS 10-03 working group advises that defining a reference list of European marine ecosystem is a top priority. These ecosystems would be considered as the functional units used in EAFM, especially to calculate ecosystem indicators, to conduct stocks synthesis or fleet based analyses, to develop advice-oriented ecosystem and bio-economic models, and more generally to analyse tradeoffs between ecology and economy.

In its 2009 report, STECF already noted that: "a first step for improving EAFM and bio-economic modelling is to define an agreed list of "reference ecosystems" (or "marinographic areas"). This scaling should take into account the limits of the RACs, and probably define sub-areas within RACs". STECF also considers that such ecosystems should be as close as possible (if not similar) to those defined by the MSFD. Some strong relationships have to be developed between EAFM and the assessment of GES, especially regarding the definition of the ecosystem indicators of GES (and the related methods).

An objective of the Marine Strategy Framework Directive (MSFD) is to achieve Good Environmental Status (GES) for descriptors (food webs, biodiversity, commercial fish and shellfish, seabed integrity) that are impacted by human activities. The role of the CFP in contributing to the achievement of GES is clear in the text of the MSFD. First, fisheries regulatory measures needed to achieve GES were to use the CFP to the fullest extent possible, and second, the CFP and future revisions of the CFP should take into account the environmental impacts of fishing and the objectives of the MSFD. The MSFD provides a clear context for the 2012 revision of the CFP, since the CFP is required to be used to manage the environmental impacts of fishing to the extent necessary to achieve GES.

At the same time, implementing EAFM is a specific task, that has to be conducted in respect to -and in close collaboration with- the MSFD, but whose purpose is not (or not only) to ensure GES. On the other hand, EAFM aims to take into account not only ecological sustainability (and GES), but also economic profitability and social fairness. Its major objective (its specific value-added) is to analyse tradeoffs between ecology, economy and social aspects, the tree pillars of the sustainable development of fisheries.

[1] Communication from the Commission to the Council and the European Parliament - The role of the CFP in implementing an ecosystem approach to marine management [COM(2008) 187 final] /* SEC/2008/0449 final */

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Therefore, and even if flexibility is required, STECF is still of the opinion that defining reference ecosystems is a good idea to facilitate an EAFM. STECF considers that the candidate list suggested by the SGMOS 10-03 working group as a first proposal submitted for discussions meets three important requirements:

i. it is very close to the MSFD Marine Eco-regions (except that boundaries are defined by ICES divisions or subdivisions limits in place of EEZ boundaries);

ii. it matches to RACs areas;

iii. it relates, at least for a large majority of suggested ecosystems, to entities commonly used in many research programs, management rules or committees (e.g. Baltic sea, North Sea).

STECF also note this list is very close to the one proposed by ICES (2004) in response to EC request about appropriate Ecoregions for the implementation of an ecosystem approach in European waters. The main differences are as follows:

. ICES list included four northern Ecoregions which are not considered in the SGMOS 10-03 report: Greenland and Iceland Seas, Barents Sea, Faroes and Norwegian Sea. Inclusion of these ecoregions in the candidate list seems to be appropriate.

. SGMOS 10-03 suggest to divide the Celtic Sea Ecoregion of ICES within three ecosystems (the West of Scotland/Ireland, the Irish Sea and the Celtic Sea restricted to divisions VIIe-k), and to divide the South European Atlantic Shelf Ecoregion within two ecosystems (the Bay of Biscay including VIIIabd, and the Iberian coast). STECF note these subdivisions are commonly used in many studies performed by ICES and STECF and are not incompatible with a more aggregated approach when needed.

. SGMOS also suggest dividing the Adriatic-Ionian Seas Ecoregion in two parts (Adriatic sea and Ionian sea) which conforms to many studies and published works.

. Finally, SGMOS list include two ecosystems for the Açores and Canarias/Madeira, while theses areas were not explicitly considered in the ICES consultation and were partly included within a larger Oceanic northeast Atlantic Ecoregion.

It is therefore necessary to be confident that the ability to deliver the EAFM will not be compromised by the present set of defined eco-regions. In order to achieve this STECF **recommends** a Working Group (see below) should undertake a comparative analysis of results obtained using the present eco-regions with results obtained using the proposed list of eco-regions (above) to assess if changing the regional boundaries actually makes a significant difference in the results obtained.

. Implementing advice-oriented models

The SGMOS 10-03 working group suggests a two steps procedure to implement ecosystem and bio-economic models in each reference ecosystem, in an advice-oriented perspective. The first step would be to build some references models for each reference ecosystem. A possible way to achieve this may be through a specific call for project managed by DGMARE. STECF notes that the Current FP7 call KBBE.2011.1.2-09 " Beyond MSY) , may be an appropriate framework to develop such models The second step would be to set up one or more working groups charged to apply such reference models on a regular basis, updating the diagnosis on ecosystem health and investigating compromises between ecological and economical objectives.

STECF considers that developing and implementing such models would be very useful and should be encouraged in a flexible way. STECF suggest that one possible and initial way forward could be to convene a working group on this matter, under the auspices of SGMOS. Such a working group could undertake a case study of a single ecosystem by adapting existing ecosystem and bioeconomic models. The WG objective would be to test the models' ability to provide an assessment of the fishing impact on ecosystem functioning, to analyse various management scenarios (possibly defined by a specific request of the Commission), and to try to develop a fleet-based feasibility modelling approach in order to assess or optimise the tradeoffs between ecological impacts and economical performances. More generally, the objective should be to test the models' ability to provide informative advice in the framework of EAFM.

The WG may also be asked to give further thought to the potential utility of the project suggested by the STECF-SGMOS 10-03 WG for the further development of ecosystem and bioeconomic models in European ecosystems and to specify what such a proposal should aim to deliver. Another way forward would be to ensure that the outcomes from current and future relevant research programmes are use to inform on the EAFM.

. *Promoting an advice-oriented ecosystem approach in various existing committees*

The SGMOS 10-03 report makes several recommendations in relation to improving process, in particular the establishment of permanent expert groups to deliver operational ecosystem advice, e.g. by up-dating assessments annually. STECF agrees that this is a good idea and recognises the good progress made by the ICES Expert Groups established under the Regional Seas Programme, notably; the North Sea and Baltic Sea groups.

STECF was unable to fully discuss all of the recommendations made by the WG on improving process. Further consideration on improving process and the WGs recommendation to further improve the DCF by taking into account proposed ecosystems instead of the larger ecoregions currently specified, could be taken up by STECF should the Commission give these issues sufficiently high priority.

As a conservative initial step, STECF **recommends** that a WG be convened under the auspices of STECF-SGMOS, and scheduled for 2011 with the following Terms of Reference:

1. to update and improve the assessment related the North Sea and the Celtic Sea ecosystems,
2. to aggregate new results from various committees or programs (especially those potentially issued from the experimental group on modelling, mentioned above),
3. to discuss new developments of EAFM and on the best way to develop synergies between EAFM and GES.
4. To assess the sensitivity of such assessments to changes in the boundaries of eco-regions.

Additional STECF comments on data needs

ICES provides stock assessments and has the potential to provide a range of ecosystem indicators by stock. The JRC collects and maintains two major sources of data, the SG MOS catch and effort database and the Economic data for the AER. However, these three sources of information are aggregated in different ways. For example the ICES data is stock based, the economic data has information on costs and investment at fleet segment level and landing value and volume data with a level of spatial information which in some cases (but not all) allows this to be matched to stock. The Effort data is assembled with a high degree of spatial resolution and catches can in most cases be allocated to stock.

These data sets support a number of evaluations: economic evaluated by fleet segment, evaluations of management plans by stocks of groups of stocks, and advice on fishing targets and fishing mortality rates. They are also potentially useful for ecosystem status evaluation.

In order to provide an ecosystem status evaluation it is necessary to divide the whole EU area into a regions that have coherence as an ecosystem such as the one proposed by the STECF-SGMOS 10-03 WG. However, there are other area based management requirements such as ICES Eco-regions, the Member States regional responsibilities, and the description of marine regions and subdivisions relevant to implementation of MSFD (Article 5(2) of 2008/56/EC Marine Strategy Framework Directive). Under MSFD Member States sharing a marine region or subregion shall cooperate to ensure that, within each marine region or subregion, the measures required to achieve the objectives of the Directive are co-ordinated. This includes the programme of measures to achieve Good Environmental Status (GES). Four of the eleven measures of GES (Food Webs, Biodiversity, Seabed integrity, Commercial Exploited Fish and Shellfish) can be impacted by fisheries and fisheries will need to be managed to ensure GES is achieved. The region or sub-region is in effect, therefore, the management region for the MSFD.

In section 4.3 on the review of the SGECA 10-03 report STECF developed possible TOR for a workshop on possibilities to collect disaggregated economic data with an additional area code. Furthermore, it is intended that possibilities for collection of disaggregated costs data will also be assessed by that workshop. If such a disaggregated data collection is possible it will allow STECF to assign costs and earnings data to the different eco-regions.

Thus we have competing requirements these different sources. To answer these diverse requirements, it is important to ensure that data can be used to support the different spatial and fishery based units. If we were to add to the existing databases, sufficient metadata to link the information available to the different spatial and fishery aspects and define and develop appropriate data queries, we should be able to calculate and deliver the different indicators required. It may be that it will not be possible to directly assign all data uniquely to regions, but where stocks or fleets overlap well defined ecoregions, these should be in a minority. In this case metadata can be used to make multiple or fractional allocations of the indicators to region.

References

Caddy, J. F., 1998. Deciding on precautionary management measures for a stock and appropriate limit reference points as a basis for a multi-LRP harvest law. NAFO SCR Doc. 8, SN 2983, 13pp.

ICES 2004. ICES response to EC request for information and advice about appropriate ecoregions for the implementation of an ecosystem approach in European waters, 27 pp.

STECF/SGMOS-10-03   WORKING GROUP REPORT

DEVELOPMENT OF THE ECOSYSTEM APPROACH TO FISHERIES MANAGEMENT (EAFM) IN EUROPEAN WATERS

6 - 10 SEPTEMBER, Rennes, FRANCE

1. SUMMARY ON THE DEVELOPMENT OF THE ECOSYSTEM APPROACH TO FISHERIES MANAGEMENT (EAFM) IN EUROPEAN SEAS

A first attempt to develop scientific advices in the frame of EAFM

- The SGMOS 10-03 working group was requested to develop a feasibility approach for providing useful advice on the ecosystem health considering two case studies: the North Sea and the Celtic Sea. This approach was based on the reconstruction of long time-series of catch, the analysis of mean indicators and stocks trajectories derived from ICES stock assessment results and the analysis of ecosystem indicators.

- The Celtic Sea ecosystem appears to be globally overexploited. Over the last 15 years, total landings are sharply declining and a significant decrease in the mean trophic level of catch is observed. Although the fishing pressure seems to decrease in the last decade, it is still very high and stocks remain overall in a bad status, with biomass almost at the Bpa limits. In the last years, 6 among the 8 stocks assessed by ICES in this area were outside of the limits defined by the precautionary approach, all of them being overexploited (with $F>F_{0.1}$).

- As the Celtic Sea, the North Sea ecosystem cannot be qualified as being exploited sustainably. Total landings peaked in the mid 1970s before decreasing by more than two-fold during the last three decades. The mean fishing mortality has been constantly decreasing since 1985, accelerating the decrease observed in the total catches. At the same time, the overall spawning stocks biomass has not changed, indicating that the exploited ecosystem is not recovering. All the 10 stocks assessed by ICES are overexploited, 40% of them being unsustainably exploited. Ecosystem indicators confirm the strong fishing pressure exerted on the ecosystem and show that the ecosystem health is at least not recovering and could be still deteriorating. We conclude that the decrease of the fishing pressure has not been important enough and/or long enough to allow recovery of the North Sea ecosystem from the highly exploited state.

- The SGMOS working group was also requested to develop a fleet-based analysis. Indicators were derived from ICES assessments to characterize the fleet impact on the exploited fraction of the ecosystem. Due to the poor quality of the available data, results should be considered as preliminary. Nevertheless, from a methodological point of view the test was successful. Partial mortalities and sustainability indices allow to highlight significant contrasts between the various fleet segments operating in the ecosystem in term of their direct impact on the ecosystem. Assessment diagrams show whether each fleet segment, on average, sustainably exploits the stocks.

- The SGMOS working group analysed indicators of the economic performance (from AER 2010) of the major fleet segments operating in the two ecosystems. Tradeoffs were examined crossing ecological impacts and economic performance. Even if preliminary, results from such environmental assessment clearly highlight contrast between fleet segments. Some receiving higher subsidies than others exhibit negative profits and have severe impacts on the resource, while others appear more virtuous. Such type of results constitutes a step toward a fleet-based management within the ecosystem and strengthens the argument that subsidies don't solve the short term economic problems of industry while probably increasing pressure on ecosystems. The benefit of developing positive or negative economic incentives in order to favor or reduce some fleet segments or to encourage fleets to improve their fishing practices could also be highlighted.

- The SGMOS working group concludes that the feasibility analysis conducted using the North Sea and the Celtic Sea as case studies confirms that such ecosystems represent the appropriate level:
  . to draw syntheses on stock status and analyze trends in ecosystem indicators,
  . to study ecological impacts and economic performances of fleet segments,
  . to analyze tradeoffs between economy and ecology in order to develop a fleet-based management of fisheries,
  . to develop models devoted to scientific advice in both ecological and economical frames (see below).

  The ecosystem also appears to be the right entity to improve the dialogue and involve stakeholders (with regards to RACs) and to build integrated management plans.

Recommendations for the Development of the EAFM in European Seas

- The SGMOS working group highly advices that defining a reference list of European marine ecosystems is the top priority for implementing EAFM. This suggests that the list of 14 ecosystems presented in Table 5.1 (p.62) should be considered. This list could be submitted to the advice of STECF and possibly to a group of experts before being submitted for consultation with RACs and formally adopted by the Commission.

- The SGMOS working group considers that operational models should be urgently implemented in order to provide scientific advice that can be effectively used in the frame of EAFM. This could be undertaken in the two following steps:

  1. First, a set of a limited number of reference models should be developed or adapted for each one of the 14 European marine ecosystems. The SGMOS working group suggests this could be done trough a specific call for projects managed and sponsored by DG MARE. A scientific committee could be set up to validate models as reference to be used within the scientific advice framework.

  2. A specific working group should be set up to run the reference models on a regular basis updating the diagnosis on ecosystem health, simulating various options for fisheries management, and investigating compromises between simultaneous and often incompatible biological objectives (such as the objective to reach the FMSY simultaneously for every stocks) and between ecological, economical and social objectives. In practice, SGMOS suggests that such a group should be set up rapidly, starting with a very limited number of ecosystems. On the medium term several groups will become necessary, for instance according to RACs.

- The SGMOS working group considers that setting up a new organisation of working groups devoted to the scientific advice, on an ecosystem basis, is a requirement to enforce implementation of the EAFM. SGMOS suggests starting discussions with the other STECF groups and with ICES (and potentially with GFCM) in order to promote an advice-oriented ecosystem approach. SGMOS especially suggests to:

  . Draw the long-term picture of trends in catch and fishing effort in all European reference ecosystems. This is likely to require a specific project developed in close relation with the ICES-SGHIST;

  . Routinely estimate values of ecosystem indicators (and work on methods). It would be the task of a specific working group, possibly the ICES WGECO (at least for Atlantic and Baltic waters);

  . Assess the stocks. This is part of the EAFM and should be extended to as many as possible exploited resources. SGMOS suggests STECF should recommend that an increasing proportion of the stocks targeted by European fisheries should be assessed. In addition, an analysis is required in each ecosystem to determine which part of the exploited stocks is currently assessed and how this could be improved (especially defining strategies for non-targeted species);

  . Perform fleet-based analysis including, for the main fleet segments, the environmental assessments and evaluation of their economic performances. This should be the task of a specific group, possibly under the auspice of SGECA;

  . A first SGMOS working group could be in charge of updating and running each year the reference ecosystem and bio-economic models (see above); this working group should also take into account specific results from other groups (e.g. ICES WGMIXFISH, etc);

  . Finally, a second SGMOS annual meeting could be in charge of building synthesis and formalize scientific advice under the authority of STECF. An annual EAFM report would be very valuable; it could be the product of this group based on an integrative approach of results obtained by several bodies.

- Therefore the first step to implement EAFM in European Seas is to officially define the reference list of European marine ecosystems. Secondly, two major improvements should be promoted. On one hand, reference ecosystems should be considered in all data collection programs related to fisheries, resources, habitats, etc. It clearly applies to the DCF that should be revised. On the other hand, reference ecosystems should be considered as the functional units used in many working groups from ICES and STECF. It could imply changes in the organisation or in the terms of reference of several working groups. More generally, SGMOS recommends that such reference ecosystems should be considered in most research programs. The use of a single geographical level in various groups, projects, programs or committees would allow a more efficient aggregation and/or synthesis of results, experiences and knowledge.

Acknowledgement

The STECF meeting of the SGMOS-10-03 Working Group on the Development of the Ecosystem Approach to Fisheries Management (EAFM) in European Seas was drafted by the STECF-SGMOS 10-03 Working Group held in Rennes, France from 6-10 September 2010. The Report was reviewed and adopted by the STECF at its 35th plenary session held in Brussels from 8-12 November 2010.

STECF acknowledges the extensive contribution made by the following participants:

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2. INTRODUCTION – GENERAL APPROACH AND METHOD USED

2.1. Terms of Reference

Background

During its 30th plenary meeting, following upon the Commission request, STECF advised on the way to develop ecosystem approaches and bio-economic modelling (PLEN-09-01). STECF firstly made general comments and suggestions on the implementation of EAFM and bio-economic modelling. Secondly, STECF discussed a non-exhaustive list of currently available tools that seemed useful, and that could be more widely used or tested in Europe, in order to progress in implementing EAFM (see report in Appendix 2 of the present document).

STECF recommended that "In order to set out a roadmap to further consider the possibilities for implementing an ecosystem approach, a STECF subgroup should be set up under the auspices of STECF-SGMOS, with participation of ecologists, biologists and economists".

STECF concluded that a pragmatic first step should be to use the tools described in its report, to show changes in the biological status of the species and to include economic information in the assessment.

Terms of Reference

Based on the STECF-09-01 report, the working group was requested to develop a feasibility approach to provide some useful ecosystem advices, considering two case studies: the North Sea (IIIa, IVa-c, VIId) and the Celtic Sea (VIIe-k).

For these two case studies, the working group was requested to gather existing knowledge and to analyse all available data (or identify lack of data and suggest improvement regarding data):

1. to examine trends in total catches and catch by species, and trends in fishing effort (possibly by country and/or fleet) over the past years, trying to take into account a period of time as large of possible (from 1950 if possible). The objective is to provide a comprehensive framework of the main characteristics and of the dynamic of the whole fishery.

2. to build an integrated synthesis of the stocks status and stocks trends at the ecosystem level, using tools listed in the STECF-09-01 report (Garcia and De Leiva 2005; Gros 2008; Froese and al. 2008) or all other relevant equivalent tools. Such representations should include the degree of stocks dependency to the considered ecosystem, and the representativeness of the considered stocks for fisheries occurring in the ecosystem.

3. to build a fleet-based synthesis, using fleet segment as defined by DCF. Such synthesis should include descriptors (and possibly trends analysis over the recent years) of: the fleets economic performance, and their respective contribution to the fishing mortality of each stock, their economic dependency on stocks, the co-occurring bycatch species (commercial and non-commercial).

4. to analyse ecosystem indicators computed by ICES or JRC, based on the list of agreed to by ICES (see table 5.1 in Appendix) and on DCF. If necessary, these indicators could be recomputed at the scale of the two ecosystems under study. Additional indicators may be considered following suggestions from STECF on SSB and Trophic levels (see Appendix). Such calculations should cover a period of time as long as possible, available data permitting, with the objective to assess the ecosystem health on a long time perspective.

5. to calculate standardised indicators of economic performance of fleets, and to analyse trends, based on the indicators used in AER (e.g. gross revenues, gross value added, net profit). Other economic indicators can also be considered (and computed when possible), to characterise the fleets dynamic and performance.

6. to review and discuss models that are already implemented or could soon be implemented in the two ecosystems to identify tools that would be useful to compare various fisheries management options, in an ecosystem perspective. This review should include both trophodynamic models, such as EwE or ET, and multi-species multi-fleets bio-economic models.

7. to discuss the appropriateness of the considered ecosystems (i.e. NS and Celtic Sea) as reference units for implementing EAFM and suggest approaches that should be used to define an agreed list of "reference ecosystems" in European waters.

8. to suggest a general format that could be used for the publication by STECF of an annual EAFM report and suggest an organizational structure that would be responsible for addressing future ecosystem analyses.

9. more generally, based on this first feasibility study, the working group is invited to comment regarding the best way to improve EAFM implementation in European waters.

2.2. Data used

Various data bases were specifically prepared or made available for the SGMOS 10-03 working group. The major one, prepared by JRC (John Anderson), is based on the 2010 data call for the Annual Economic Report [2]. It was used for all the economic analyses performed by the working group and includes three worksheets:

1) Cap_Emp_Econ_CVal_Ent_Pivot: This worksheet contains a pivot table which includes all Member States (that submitted) fleet capacity, employment, fishing enterprise, costs and earnings and capital value data.

2) Effort_Pivot: This worksheet contains a pivot table which includes all Member States (that submitted) effort data e.g. Days at Sea, Fishing days, KW and GT Days, fuel consumption, and other effort variables. You can select the country and fleet segments as above.

3) Landings VALUE 02-05 Pivot, Landings VALUE 06-08 Pivot, Landings WEIGHT 02-05 Pivot, Landings WEIGHT 06-08 Pivot: These 4 worksheets contain the total volume and value of all species landed by all countries (that submitted data) for the years in question.

Others data sets, which have free access, were downloaded from the ICES website and were made available to the working group:

- The ICES Statlant database was used to analyse trends in catches over the long period. This includes three sets of data:
  . ICES5072: Catches per species, per country and per division, from 1950 to 1972,
  . ICES: Catches per species, per country and per sub-division, from 1973 to 2008,
  . STOCKS: catches per stock, per country and per sub-division, from the beginning of assessment, until 2005

- The FISHSTOCK.DB dataset gathers all results of ICES stock assessments until 2009 and especially includes the following tables:
  . table Fishdata: SSB, Y, F, R,...
  . table Limits: F and B pa and lim
  . table yieldrecruit: data required to calculate yield per recruit, for some stocks

- DATRAS (http://datras.ices.dk/) is the ICES data base gathering data on surveys that could be used to calculate some ecosystem indicators included in the list specified by the ToR. This includes:
  . for the Celtic sea : English surveys standardized since 1898, and French Evhoe surveys covering all the Celtic Sea (VIIe,f,g,h and j) and Bay of Biscay since 1997 ;
  . for the North sea: IBTS since 1960s, but standardized since 1983.

[2] The communication from DG MARE on usage of data submitted to JRC during data calls specifies the conditions required to use such data. As a result, they are fully available for the SGMOS working group, but can only be used during the working group itself. Results based on the analysis of these data can be published only after they have been presented in the report of the working group.

2.3. Methods

. ToR 1. Long term trends in catches and fishing effort

The study group examined the trends in total landings and landings by species using the ICES Statlant database. This international database on fisheries landings is coordinated by ICES. It includes landings of fish and shellfish from 20 countries, for each species at the spatial resolution of ICES divisions or subdivisions. The database provides a comprehensive catalogue of reported landings for a large number of species (223 in the North Sea). Unfortunately they are not broken down in to catches by fleet. The Co-ordinating Working Party on Fishery Statistics (CWP) organises the collection of these statistics under the Statlant programme. ICES has published these data in the Bulletin Statistique des Pêches Maritimes from 1903 to 1987, and from 1988 onwards in ICES Fisheries Statistics. Until 2009, the Statlant database contained landings by ICES subdivision from 1973. However, ICES is working on making its data more available and this year, electronic data back to 1950 became available (at the division level). Using it requires combining results from one database with another, where particular care needs to be taken to ensure that the listed species match correctly. The landings database is accessed and manipulated using an FAO database query tool called Fishstat. Fishstat can also be used to query the FAO international fisheries landings data collated by themselves (http://www.ices.dk/fish/statlant.asp).

In the case of the Celtic Sea, data where compiled over the 1973-2008 period, per country or per species for the subdivisions VIIe-k. Some landings referred to subdivision VIIde (English Channel). According both to the ratio of surfaces and to the ratio of landings specifically affected to VIId or VIIe, 64 % of these landings were assumed to come from the Celtic Sea (i.e. from VIIe). Times series of landings, per countries and per species categories (using ISCCAP groups) were extended to the 1959-1972 period, assuming also that 27 % of the landings reported from VIIa-f subdivisions were caught in the Celtic Sea.

In the case of the North Sea, which consists for SGMOS of 5 divisions, i.e. IVa,b,c IIIa and VIId, we only used divisions IVa,b,c for this exercise. To reflect recent catch profiles, data were sorted using the average catch in the years 1997-2007. The top 20 species by catch weight were chosen, accounting for those whose individual contribution to the total North Sea catch is greater than 0.5%. Landings data extending back to at least 1892 and to the early 1800s for some species are becoming more readily available and have been previously compiled by Mackinson and Pinnegar.

It is important to note that the landings reported in ICES Statlant do not reflect the total removals or 'catches' by fleets, because many species are caught and discarded. Using specific data from discard surveys, ICES stock assessments working groups estimate the amount of discards when trying to determine the total catch of each species (Fig. 2.1). Thus to ascertain the catches, it would have been advisable to work with the catch data used by the stock assessment working group and reported in the ICES stock datafiles. Nevertheless, additional complications arise when the catches of one species within a region come from more than one stock, or when one stock expends outside of the studied ecosystem. More importantly, stock assessments only cover the last decades and do not provide a long term perspective on catch trends. Thus catch reconstruction was out of the scope of the SGMOS 10-03 working group and only trends in landings were analysed. Such a reconstruction should been conducted in the near future, based on reasonable assumptions and using all available data or models, and providing a more comprehensive overview on the long term trends in the total removal from ecosystems. Coordination with ICES appears useful to determine if its study group on the history of fisheries (SGHIST) is able to provide a focus for the compilation of such data.

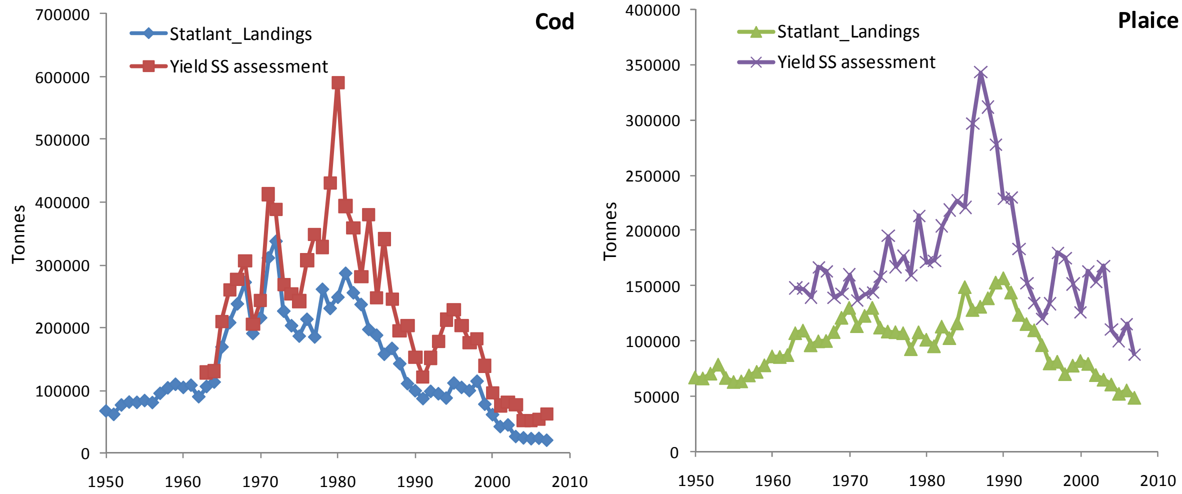


Figure 2.1. Difference in ICES Statlant landings and landings used in stock assessments. The examples of cod and plaice in the North Sea.

Regarding fishing efforts, the working group was not able to identify any source of information allowing for a reconstruction of long term trends. Data collected under the DCF or DCR only cover the very last years. Many scientific works or data related to specific fisheries and/or specific periods of time probably exist in the literature, but obviously the working group had not enough time to collect and analyse such information, what should/could be the goal of a specific research project (possibly under the auspice of the ICES-SGHIST study group). As a first step, the working group analysed the trends in effort of the tuning fleets used in ICES stock assessments. Such data covers the last decades and can be obtained from WG assessment reports. As a test, these fishing efforts were mapped for the North Sea, based on the fleet categories defined in the Data Collection Framework. Results are presented in the section related to the North Sea (& 4.2).

. ToR 2. Stocks-synthesis

The proportion of exploited species that are monitored through stock assessment translates the amount of awareness about the ecosystem. The proportion was computed using landings compiled in the previous section. The proportion of stocks assessed compared to total landings was computed for the 1973-2008 period.

For each stock subjected to an assessment, mean F, Recruitment index, total catches and spawning stock biomass were used to produce a synthesis of multiple stock trajectories. Mean F and recruitment index were averaged over the adequate number of species while landings and biomass were summed. The recruitment index is computed as the ratio of R in year y on the average recruitment for years that are common for all species (1972-2008 in the Celtic Sea and 1967-2008 in the North Sea).

The current status of the assessed stocks was summarized using three reference points for biomass and fishing mortality: the precautionary reference points for biomass and fishing mortality (Bpa and Fpa), the point at maximum yield per recruit (Bmax and Fmax), and at $F_{0.1}$ ($B_{0.1}$ and $F_{0.1}$). All these reference points were found in stock assessment reports or could be computed from the yield per recruit table found therein. The present status of each stock is that of the latest available assessment (2004, 2007 or 2009) depending on species.

These results were presented adapting the synoptic method developed by Garcia and de Leiva Moreno (2005) in which the current F is compared to reference points (here $F_{0.1}$ and Fpa) by normalizing with these two reference points. Thus, the relative F (F*) is obtained with: $F^* = (F_{current} - F_{0.1})/(F_{pa} - F_{0.1})$ while the relative biomass is $B^* = (B_{current} - B_{pa})/(B_{0.1} - B_{pa})$. Trends in stock status were obtained using the stock status of each year for which we could calculate F* and B*.

As the starting and last year of assessments varies with species, it was impossible to consider all species for the entire period. Thus, several combinations of species and period covered were compared to identify possible change in trajectories but only one or two combinations were retained.

. ToR 3. Fleet-based synthesis

The study group was asked to build a fleet-based synthesis following the fleet segmentation defined by the DCF. Such synthesis had to include the respective contribution of each fleets to the fishing mortality of each stock, and the fleet economic dependency on stocks. The economic data for 2008 were collected following the new fleet segmentation in the DCF. In the DCR (2002 – 2007) a slightly different segmentation was used. The economic subgroup, therefore, decided to use only the 2008 data on value of landings to define the most important fleet segments.

French data on Celtic Sea landings were reported only for area VII without a separation between sub divisions. The French fleet has a huge share of the overall landings in the Celtic Sea. The working group decided to add two French fleet segments (which can be divided in 4 sub-segments) out of expert knowledge to have a better coverage of the whole fisheries in the Celtic Sea. Thus, these fleet segments refer to the whole area VII and not only to the Celtic Sea. For Spain no data on value of landings was available.

In the case of the North Sea, the data availability was better and the group able to choose the most important segments having data from every country (10 most important fleet segments with a coverage of 61% of the total value of landing in the North Sea).

After choosing the fleet segments, five types of indicators were calculated for each fleet segment.

i. The group looked at the species composition of the landings of those segments and calculated for the five main species the percentage of these species on the total landings (in value). This was done to assess **the dependency of the selected fleet segments on certain stocks**.

ii. The value of landings from the Celtic or North Sea was compared to the total value of landings of the fleet segment. With these information's it is possible to calculate **the dependency of the fleet segment on the studied ecosystem**. A good example is the German Beam Trawl segment VL1218 were 100% of the shrimp landings are from the North Sea. Therefore, this segment is totally dependent on the catches in the North Sea.

iii. For all stocks assessed by ICES, the contribution of each fleet segments to the total fishing mortality was calculated (the partial F is deduced from the total F issued from the ICES working group, according to the proportion of the total catch due to the considered fleet segment). This indicator is a measure of **the impact of the fleet segment on the most important stocks** present within the ecosystem. However, in some cases the most important species (at least from a value perspective) came from stocks not assessed by ICES. Therefore, the group was not able to assess the contribution of the fleet on the fishing mortality of those stocks.

iv. The sum of all the partial F applied by each fleet to the most important species could be considered as **an index of the impact of each fleet segment on the ecosystem**. Of course this index is partial and only measures the global impact of the fleet on the exploited and assessed stocks; indirect impacts, trough the food web or on habitat, are not taken into account (this require using models). Nevertheless, the total partial F per fleet is an index of the pressure applied by the fleet to the fishable part of the ecosystem. Of course, the index becomes more reliable as the more the number of stocks assessed by ICES increases (i.e. the more a large part of the exploited biomass is assessed).

v. For each fleet segment, **two indices of the fleet sustainability** were calculated. One is the weighted average of the normalized fishing mortalities F* for all the stocks that are exploited by the fleet and assessed by ICES. The other is the weighted average of the normalized B* for the same stocks (see above in method section on ToR2 how F* and B* are calculated for each stock, in comparison to the $F_{0.1}$, $B_{0.1}$, Fpa and Bpa reference points). For both F* and B* cases, the average is weighted by the values of the 2008 landings per stock. Thus, the sustainability index is an indicator of the mean status of the stocks exploited by the fleet. It allows assessing if a fleet segment is economically dependant on stocks that are globally in good or bad shape, compared to the reference points defined by ICES. Here too, the index reliability depends on the proportion of stocks that are assessed.

This set of indicators makes the link between fleets and stocks. It allows for in depth analyses fleet by fleet (see Appendix 6 and 7) and for more general comparisons between fleet segments at the ecosystem level (see sections 3.4 and 4.4). Such an analysis is completed by the computation of indicators of the economic performances of the selected fleet segments (see below ToR5).

. Tor 4. Ecosystem indicators

The study group was requested to analyse ecosystem indicators already computed in the North Sea and Celtic Sea, based on the list agreed by ICES (see table 5.1 in Appendix 2) and possibly using additional indicators such as the mean trophic level of catch or biomass.

In fact, no previous estimates of these ecosystem indicators were identified by the study group for the Celtic Sea. In this case study, due to time constraints, the working group was only able to calculate very simple indicators based on catches. As for the North Sea, preliminary works were previously performed under the auspice of ICES. Thus, the SGMOS study group was able to gather results from various working groups and research projects. In this section we present the method used to calculate a suite of ecosystem indicators, accordingly to the EC (2008) suggestions. The following indicators are included: conservation status of fish species, proportion of large fish, mean maximum length of fishes, size at maturation of exploited fish species, spatial distribution of fishing activities.

The first four indicators should be based on survey data, the final indicator on VMS data. For the survey data the best and most representative survey dataset should be used (e.g. for the North Sea this is the IBTS) over a period for which data collection was considered consistent (for the IBTS this is 1983), the VMS data should be based on a comprehensive set of international data over the longest consistent period available (VMS was collected from 2000 onwards but due to changing regulations there may be issues of consistency).

i. **Conservation status of fish species.** According to the report of the European Commission (EC 2008) two indicators for the conservation status of fish species can be calculated: (CSFa) an indicator of the biodiversity of vulnerable fish species that responds to changes in the proportion of contributing species that are threatened; and (CSFb) an indicator of the biodiversity of vulnerable fish species that tracks year-to-year changes in the abundance of contributing species. Both indicators shown in this report are based on the work done in the MEFEPO project also involving slightly modified methods than suggested in (EC 2008). These methods are reported in more detail in Appendix 3.

ii. **Proportion of large fish.** According to EC (2008) the proportion of "large fish" or large fish indicator (LFI) is calculated as: $P_{>40cm} = W_{>40cm} / W_{total}$, where $W_{>40cm}$ is the weight of fish greater than 40 cm in length and W_{Total} is the total weight of all fish in the sample. Results presented in this report is based on (ICES 2009).

iii. **Mean maximum length of fishes**. According to (EC 2008) the Mean maximum length indicator (MMLI) can be calculated for the entire assemblage that is caught by a particular gear or a subset based on morphology, behaviour or habitat preferences (e.g. bottom-dwelling species only). Mean maximum length is calculated as: $\overline{L_{\max}} = \sum_j (L_{\max j} N_j) \Big/ N$, where $L_{\max j}$ is the maximum length obtained by species *j*, N_j is the number of individuals of species *j* and N is the total number of individuals. Asymptotic total length (L_∞) is preferred to maximum recorded total length if an estimate is available, but it is recognised that such data may not be available for many species. The work presented in this report is based on (ICES 2009).

iv. **Size at maturation of exploited fish species.** The probabilistic maturation reaction norm indicator (PMRNI) is an indicator of the potential "genetic effects" of fishing on exploited populations. According to (EC 2008) this indicator reflecting the probability of maturing is derived from the maturity ogive (i.e., the probability of being mature) and from the mean annual growth at age as:
$m(a,s)=(o(a,s)-o(a-1, s-\Delta s(a)))/(1-o(a-1,s-\Delta s(a)))$, where a is age, s is length, $o(a,s)$ is the maturity ogive, and $\Delta s(a)$ is the length gained from age a-1 to a. Estimation of the probabilistic maturation reaction norm thus requires (i) estimation of maturity ogives, (ii) estimation of growth rates (from length at age), (iii) estimation of

the probabilities of maturing, and (iv) estimation of confidence intervals around the obtained maturation probabilities. The work presented in this report is based on two studies that show for the North Sea the PMRNI over time for plaice (*Pleuronectes platessa*) (Grift et al. 2003)and sole (*Solea vulgaris*) (Mollet et al. 2007).

v. **Spatial distribution of fishing activities.** Three indicators to describe the spatial distribution of fishing activities were put forward by (EC 2008):

.1. Distribution of fishing activities is an indicator of the spatial extent of fishing activity. It would be reported in conjunction with indicator 2. It would be based on the total area of grids (3km x 3 km) within which VMS records were obtained, each month.

.2. Aggregation of fishing activities is an indicator of the extent to which fishing activity is aggregated. It would be reported in conjunction with the indicator for 'Distribution of fishing activities'. It would be based on the total area of grids (3 km x 3 km) within which 90% of VMS records were obtained, each month.

.3. Areas not impacted by mobile bottom gears is an indicator of the area of seabed that has not been impacted by mobile bottom fishing gears in the last year. This indicator could be reported annually and would state the total proportion of the area by depth strata that have not been fished with bottom gear in the preceding one year period.

Because there were no international VMS data available when this report was being drafted the work presented is based on work done as part of the MEFEPO project and reported in Le Quesne (2010).

. ToR 5. Economic indicators

The study group was asked to calculate standardized indicators of economic performance of fleets, based on the indicators used in AER, and to discuss other indicators which can also be considered to characterise the fleets dynamic and performance. The economic indicators for the selected fleet segments (see above) were extracted from the AER (2009) and from the economic database provided by JRC. The change in fleet segmentation in the DCF makes it impossible to show trends in economic performance for the fleet segments (see section 5.1 on ToR 5 for further discussion on indicators). Therefore, only results for 2008 are presented in this report.

. Data considerations

Until 2009, the AER reports included a description of the fleet structure, activity and economic performance for each country and a focus on the performances of two main fleets by country. Since 2010, the report also includes a regional approach for Baltic Sea, North Sea and Eastern Arctic, North Atlantic, Mediterranean and Black Sea and other Regions. Days at sea, landings volume and value by country and region are described. The economic performances of the main fleets operating in these areas are also discussed. However economic performances are available for the fleets by country and it is to be noticed that these fleets may operate in several regions. The economic performance provided by fleet and country are therefore not directly related to a specific region or ecosystem.

. Economic indicators available in DCF and AER

Appendix VI of the Council Regulation (EC) No 199/2008 on Data Collection framework lists the following economic variables to be collected by fleet and country.

Variable Group	Variable
Income	Gross value of landings
	Income from leasing out quota or other fishing rights
	Direct subsidies
	Other income
Personnel costs	Wages and salaries of crew
	Imputed value of unpaid labour
Energy costs	Energy costs
Repair and maintenance costs	Repair and maintenance costs
Other operational costs	Variable costs
	Non-variable costs

	Lease/rental payments for quota or other fishing rights
Capital costs	Annual depreciation
Capital value	Value of physical capital: depreciated replacement value Value of physical capital: depreciated historical value Value of quota and other fishing rights
Investments	Investments in physical capital
Financial position	Debt/asset ratio
Employment	Engaged crew FTE National FTE harmonised
Fleet	Number Mean LOA Mean vessel's tonnage Mean vessel's power Mean age
Effort	Days at sea Energy consumption
Number of fishing enterprises/units	Number of fishing enterprises/units
Production value per species	Value of landings per species Average price per species

From these data, the following economic indicators are described for each fleet in the AER:

Economic Indicators	Unit
Income	(mEUR)
Gross Value Added	(mEUR)
Cash-flow	(mEUR)
Profit	(mEUR)
Other economic indicators	
Employment	(FTE)
Investment	(mEUR)
Effort	DAYS
Capacity	
Weight of landings	(1000t)
Fleet number	(number)
Fleet GT	GT
Fleet kW	KW
Average characteritics of vessels	
Average GT	GT
Average kW	KW
Average age	year

The AER describes for each fleet (when data are available):

- the evolution of the capacity of the fleet in terms of number of vessels, gross tonnage and kW
- the evolution of income, cash flow, profit and gross value added.

Economic indicators described in the AER are relevant indicators to describe the economic performances of fleets in a studied ecosystem in the perspective of an EAFM.

. Others Economic indicators

Another useful indicator to be calculated would be the margin over variable costs associated with each ecosystem. This indicator can be calculated as the difference between incomes and energy and other variable costs (available in the DCF list of data to be collected by Member States). Margin over variable costs has been used in papers to explain the dynamic of allocation of effort between areas (or metier) as an indicator of profitability of the area (or the metier) (see for example Soulie and Thébaud, 2006).

. ToR 6 to 9. Models – General comments on the implementation of the Ecosystem Approach to Fisheries Management (EAFM)

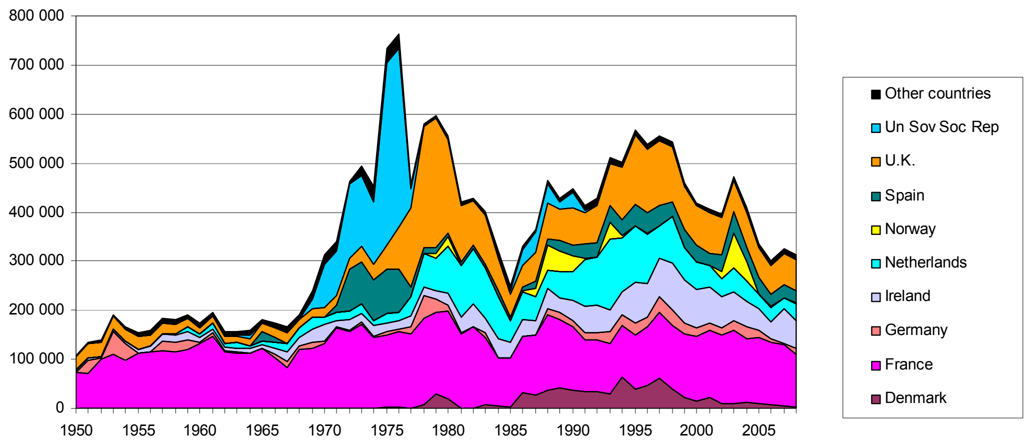
The working group was asked to review existing models that could be used in both the Celtic Sea and the North Sea ecosystems, in order to analyse and compare various fisheries management options (ToR 6). This review was based on expert knowledge and was in fact easy to complete because such models, applied to the two specific ecosystems, are not numerous at the moment. Thus, the participants discussed the point and formulated general comments and recommendations regarding how to improve models implementation in the near future, what is of course a crucial step of EAFM.

In the same way, terms of reference 7 to 9 refer to general questions regarding EAFM implementation. Comments and recommendations, based on expert's discussions, are presented in Chapter 5. This especially refers to:
. A critical review of the approach tested on the Celtic Sea and North Sea ecosystems,
. The definition of a reference list of the ecosystems that have to be considered in European waters,
. Recommendations on what could be (or should be, according to the working group point of view) the next steps to improve EAFM in European waters.

3. CELTIC SEA RESULTS

3.1. Long term trends in catches

From the ICES Statlant database, total landings in the Celtic Sea are estimated around 100 000 tons in 1950 and remain below 200 000 tons until the late 60s (Fig. 3.1). They strongly increase during the early 70s, mainly due to the arrival of a Soviet Union fleet and to increasing catch of mackerel and horse mackerel. The maximum total catch is reached in 1976 (760 000 t), just before the instauration of the European common waters in 1977 and the departure of the Soviet and Spanish fleets from the Celtic Sea. Since the mid 70s the total catch exhibits strong variations, with a minimum in 1985 (250 000 t) and a relative maximum in 1995 (570 000t). Over the last three decades, countries involved in the exploitation of small pelagics increase their catches (Denmark, Netherland, Norway), while Spain is coming back and new resources become targeted. At the same time, total landings exhibit a declining trend. Landings of the last 3 years (2006-08) are the smallest ones over the last twenty years (a bit more than 300 000 t).



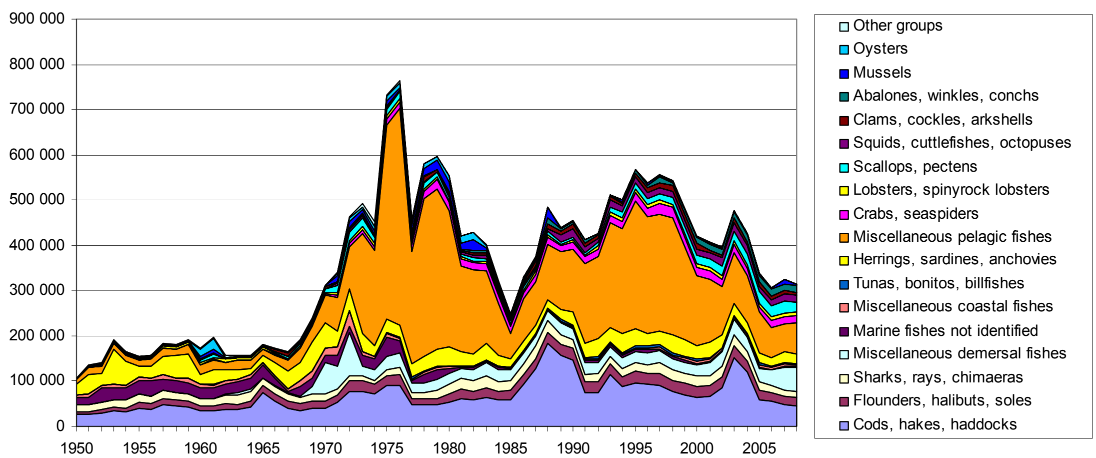


Figure 3.1 Annual landings (in tons) in the Celtic Sea, per country (top) and per ISSCAAP group (from FAO and ICES data bases)

During the 20 years following World War II, France largely dominated the fishery, its landing amounting to about two third of the total catch. Exploitation by the fleet from the Soviet Union was important during the 70s, before the expansion of the British, then the Dutch and the Irish fleets. On average for the last 10 years, the main countries exploiting the Celtic Sea are: France (34%), U.K. (18%), Ireland (16%), Netherland (11%) and Spain (8%).

From the 70s, fluctuations in total catch are mainly due mackerel and horse mackerel. For all other fish the total landing remains remarkably stable around 200 000 tons over the last four decades (with some fluctuations mainly due to blue whiting, exploited notably by Norway). Of course, this relative stability may hide changes in the landed species and changes in the amount of catch by species. For the 10 species whose stock is assessed by ICES, total landings increase in the 80s from 60 000 to almost 120 000 tons, before decreasing up to 60 000 tons over the last 10 years (Fig. 3.2). These changes especially affect whiting, herring and cod.

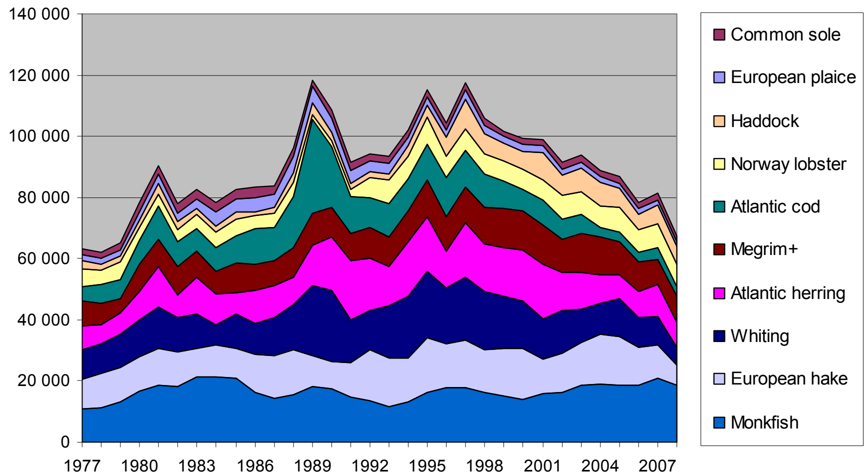


Figure 3.2. Annual landings (in tons) per species, for stocks assessed by ICES (from ICES Statlant data bases)

Invertebrate catches increase over the whole period from less than 10 000 tons in the 50s to 90 000 t per year in the last decade. Thus, crustaceans and molluscs constitute about 5 % of the total landing in the 50s, around 10 % in the 70s and almost 30 % during the last years.

In brief, this analysis of long term trends in landings show that some resources of the Celtic Sea ecosystem appear intensively fished since a least the 50s. It seems to be the case for the main demersal fish species and for some small pelagics (sardine, herring,…). Over the whole period, exploitation strongly intensifies, with more countries involved and more biological compartments of the ecosystem exploited. In a first step, intensification allows for an increase of the total landings, but since at least 15 years this is not the case anymore and total landings are sharply declining, while small pelagics, molluscs and crustaceans represent an increasing part of the catch.

3.2. Stocks synthesis

The "stocks synthesis" aims to provide an overview on what is known from all single stock assessments performed by ICES, regarding stocks caught in the Celtic Sea. In other words stocks assessment results are considered to be part of the EAFM, providing knowledge on the exploited part of the ecosystem.

- Proportion of the landings submitted to ICES assessments

The landings obtained from assessed stocks (12 species) does not follow a monotonic trend over time but generally increases until 1993 as more species are subjected to assessment, plaice and hake in 1977 and 1978 respectively, and blue whiting, whiting, megrim, monkfish and horse mackerel in the 1980s (Fig. 3.3). By 1993, the proportion reaches 70%, in part because of the pulse of landings in horse mackerel and blue whiting (Fig. 3.4). After 2004, after the effect of large horse mackerel and blue whiting landings has passed, the proportion declined to reach 30% in 2008. This is due to the combined effect of interruption in stock assessments (e.g. megrim and monkfish since 2004 and cod since 2007) and the increased landings of new species. Of course, such a change is a bad news. It has to be considered a deterioration of the information required to build a synthesis at the ecosystem scale.

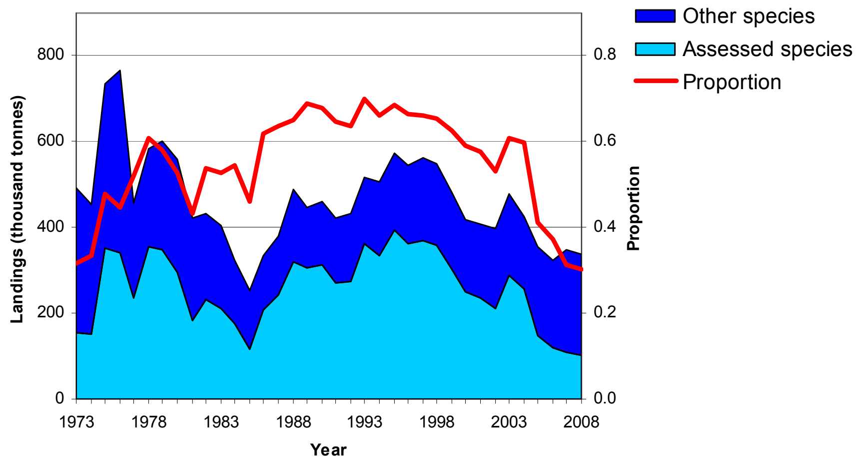


Figure 3.3. Landings for assessed and non-assessed species and proportion of landings from assessed species in the Celtic Sea

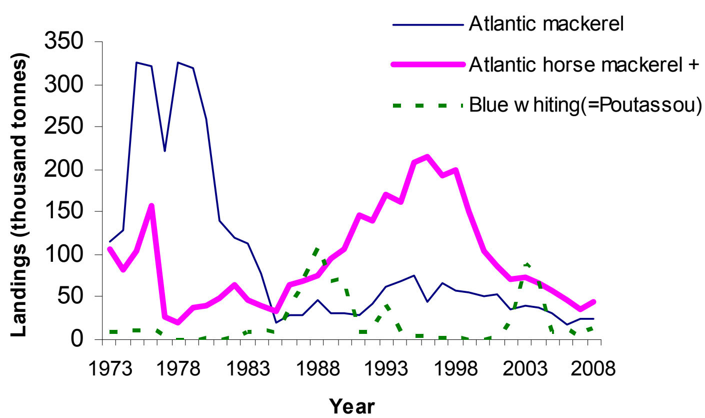


Figure 3.4. Landings for Atlantic mackerel, horse mackerel and blue whiting. Note the pulses of landings for blue whiting.

- Mean indicators of stocks status

Landings and biomass from the stock assessment of the large western stocks of hake, mackerel and horse mackerel were apportioned to the Celtic Sea using the ratio of landings which amounts to 39%, 14% and 41% respectively. Given the occasional presence of blue whiting in the Celtic Sea, it was not included in the calculation of stock synthesis. Haddock, megrim and monkfish are not presented in the following calculations because of their short time series and because they do not change the trends importantly.

Landings for the 5 first stocks (cod, herring, mackerel, sole and hake) remain stable during the 80s but declined since 1995 (Fig. 3.5). The different trajectory for the 9 stocks trend is due to large horse mackerel landings in the mid-1990s. During the same period, the first five stocks declined in biomass while F slightly increased until 1999, before significantly decreasing over the last eight years. Nevertheless, although F and landings decreased since 2000, biomasses did not increase proportionally as a response. An increase is observed for the last 3 years, but the total spawning biomass remains below its 1995 level. Individual species recruitment indices vary widely and are characterized by an isolated event of large recruitment at more than twice the average (e.g. horse mackerel in 1983, 1994 and 2001, whiting in 2008, cod in 1987). Recruitment was low for cod, herring, mackerel and sole in the early 1970s and increased toward an average recruitment during the late 1970s. The large recruitment index in 1982 is caused by exceptional recruitment (11 times the average) for horse mackerel. Globally however, recruitment has declined in the last 18 years, for all species combinations.

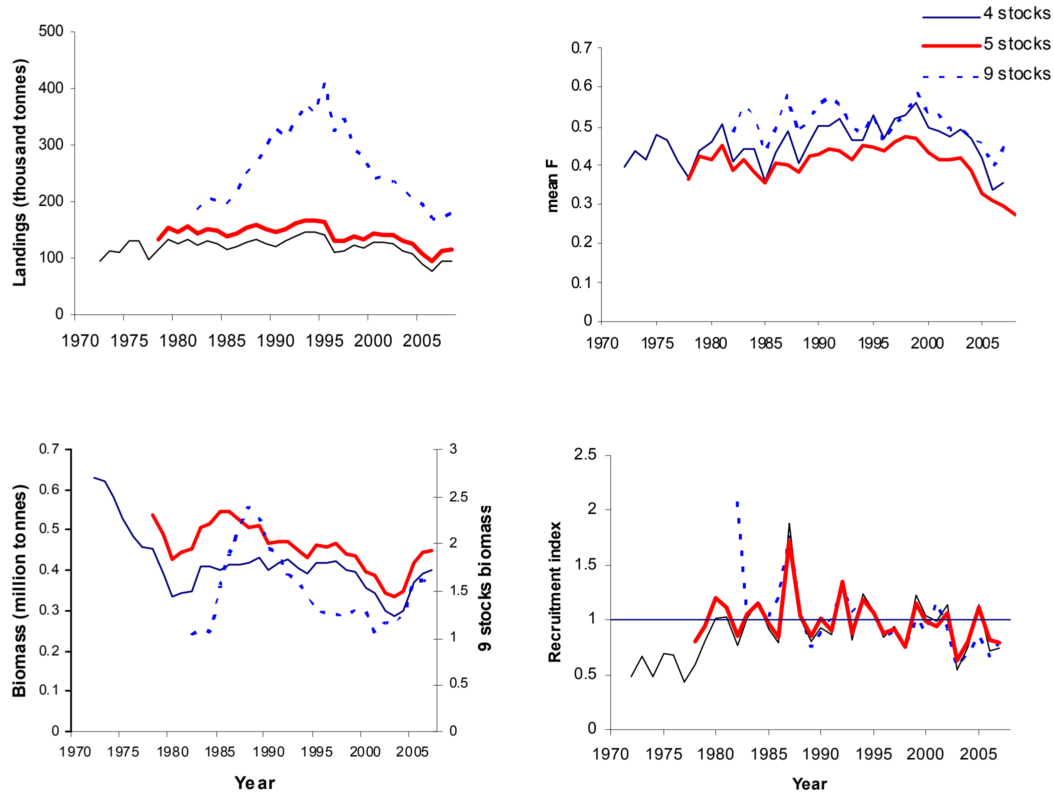


Figure 3.5. Landings, spawning stock biomass, mean F and Recruitment index for the period 1972-2008. 4 stocks: cod, herring, mackerel and sole; 5 stocks: + hake; 9 stocks: + horse mackerel, plaice (VIIe and VIIfg), whiting.

- Global stocks diagnosis

Based on the relative biomass and fishing mortality, most stocks are presently overfished (Fig. 3.6A). Plaice fg, and cod are characterized by a biomass lower than the precautionary level Bpa, although F is lower than Fpa. Whiting, plaice 7e, megrim and monkfish exhibit biomass higher than Bpa but are submitted to excessive fishing mortalities, higher than Fpa. Thus, among the 8 considered stocks, 6 fail to reach the limits previously defined as the targets by the precautionary approach. Hake and sole 7fg have the higher status (and reach the Bpa and Fpa targets), but they are still far from the $B_{0.1}$ and $F_{0.1}$ reference values, suggested by STECF as proxy of the B_{MSY} and F_{MSY} targets.

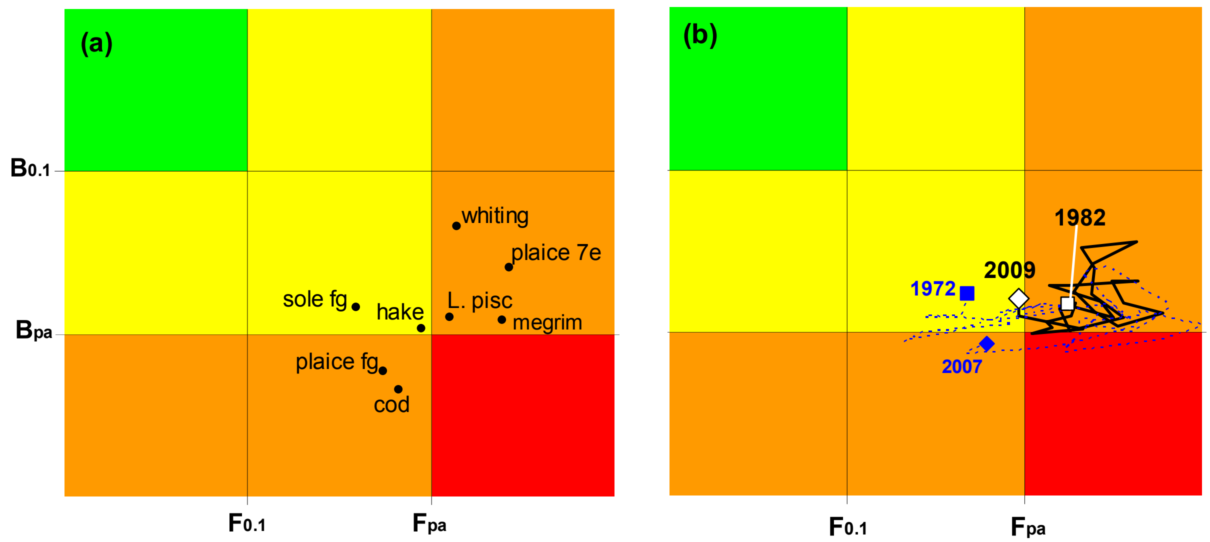


Figure 3.6. Relative biomass B* and fishing mortality F*, as compared with $F_{0.1}$ and Fpa reference points at present (a) and the indices trajectory for 2 stocks (blue dot line; cod and sole) and 5 stocks (black line; plaice 7fg and 7e, sole fg, whiting, and hake) (b).

The trajectory of these indices for cod and sole (2 stocks group) show that these stocks were constantly overfished since the beginning of the time series in 1972. This resulted in a decrease in B* in addition to several minor changes in relative biomass and F* over time. The index trajectory of the 5 stocks group (plaice 7fg and 7e, sole fg, whiting, hake mackerel and hake) show that although the level of biomass has increased during the study period, their status in 2009 is similar to that of 1982, close to Bpa and falling into the overexploited region of the graph.

- Conclusion

In brief, the stock synthesis shows that stocks assessed by ICES in the Celtic Sea are globally in a bad shape, with 6 of the 8 assessed stocks being falling to meet the limits of the precautionary approach. Although fishing pressure seems to decrease in the last 10 years, it remains significantly higher than F0.1 for all stocks. The total biomass of these stocks remains low, very close to the Bpa target. The MSY approach should lead to an increase of this biomass in the coming years.

3.3. Ecosystem indicators

The working group did not identify any previous study where some of the ecosystem indicators included in the list agreed by ICES have been estimated specifically for the Celtic Sea. Due to time constraints, the working group was neither able to calculate itself these indicators using survey data, available in the Celtic Sea since 1987 (for the UK surveys and from 1997 for the French ones), trough the ICES Datras database.

As a first run, and according to STECF suggestion (STECF PLEN-09-01, see Appendix 2), the mean trophic level of landings was calculated from 1973 onwards, using data from the ICES Statlant database. Such an indicator reflects changes occurring both in the ecosystem itself and in the fishing strategy. From that point of view, it should have been preferable to (also) calculate a mean trophic level using surveys data. Nevertheless, because almost all available resources are nowadays targeted, indicators deduced from catch often provide useful information on changes occurring in the ecosystem itself. In the same way, the mean asymptotic length was estimated from landings, for all fish and for demersal fish only (Fig. 3.7).

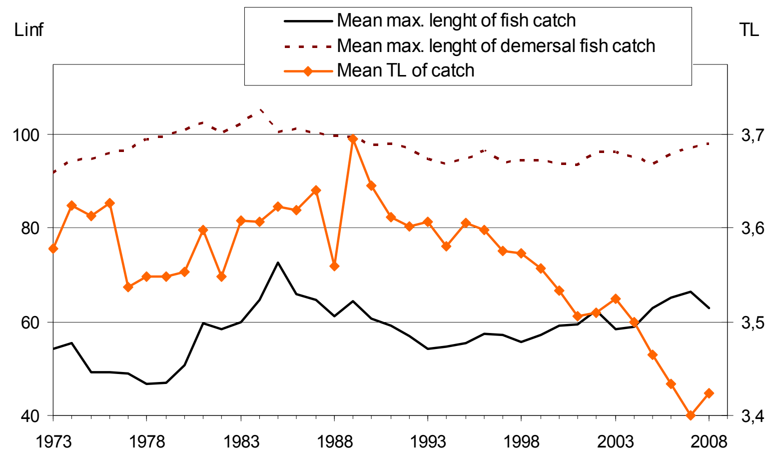


Figure 3.7 – Trends observed in the ecosystem indicators estimated from landings data, in the Celtic Sea

No clear trend is observed over the last 35 years, regarding the mean asymptotic length (for all fish, and for demersal fish as well). For all fish, fluctuations from year to year are mainly due to changes in the amount of horse mackerel caught. As for demersal fish only, the indicator remains remarkably stable.

In contrast, a strong decrease in the mean trophic level of catch is observed since the early 90s. This decrease is mainly due to the declining catch of species like cod or whiting and to an increase in molluscs and crustacean landings. It reaches 0.2 TL over the last fifteen years, which can be considered the expression of a strong "fishing down marine food web" process.

For sure, other ecosystem indicators have to be considered in the future. At the moment, mean trophic level of catch only provide a very first indication on the ecosystem state … and this indication is that ecosystem health would be deteriorating during the last 20 years.

3.4. Fleet-based synthesis

3.4.1. General results of fleets operating in the Celtic Sea - Selection of fleet segments

The Celtic Sea area considered in this analysis included the ICES areas VIIe-k. However, the analysis of landing values by country shows that the data are not always available at the subdivision level. Some countries did not provide their data during the data call (for instance Spain), while other did not filled in the database at the right level. French data are reported for the whole North-East Atlantic (FAO region 27) without distinctions of the divisions in 2008 and reported at the division VII level in 2007-2006. Therefore, no landings appear for France in the subdivisions VIIe-k whereas it is well known that French fleets are important in the Celtic Sea (Fig. 3.8). Thus, it has to be noted that selecting fleets and countries operating in Celtic Sea according to the landings data registered in VIIe-k would indeed lead to omit important fleets.

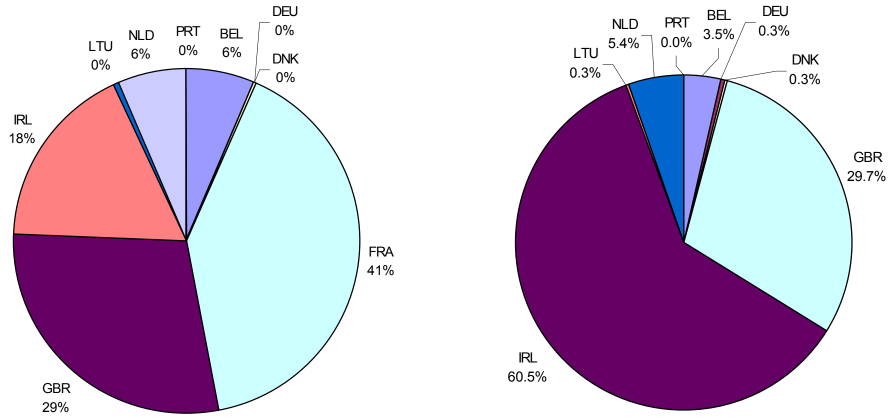
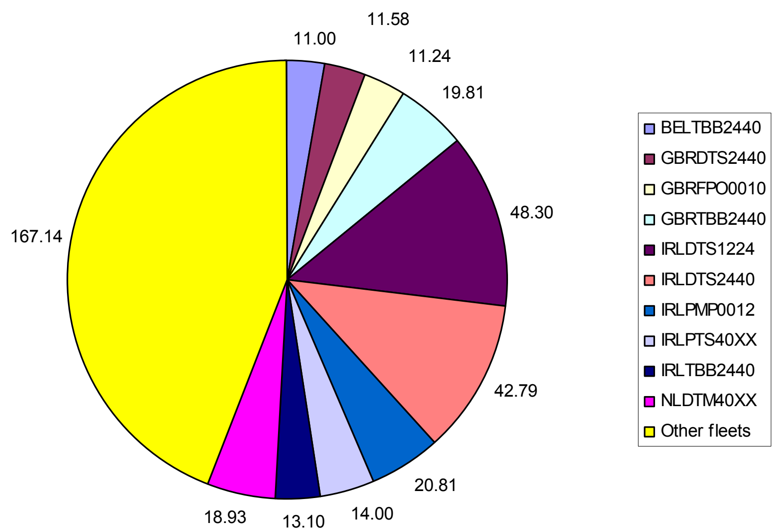


Figure 3.8. Total landing value by country, in division VII (left) and in the Celtic Sea (right). (data 2006-2008 from AEF DCF data call)

The main fleet segments operating in the Celtic Sea (area VIIe-k) have been selected on the basis of their total landings value registered in the database over the years 2006-2008 (criteria more than 2% of the total landing value) (Figure 3.9).



Figures 3.9. Total landing value (M€) per fleets segment in the Celtic Sea (mean 2006-08 values; source: 2010 data call for the Annual Economic Report).

Additionally, two French segments were considered too. Their data are only available for the whole VII division but their relative importance is well known. To sum up, 10 fleets segments were selected using Celtic Sea data (Fig. 3.9) and once the two French fleets were added, 12 fleets (Table 3.1) economic performance has been tracked in this section:

. *France:* Demersal trawlers (12-24m and 24-40m),
. *Belgium:* Beam trawlers (24-40m),
. *Great Britain:* Demersal trawlers (24-40m), Vessels using pots and traps (00-10m) and Beam trawlers (24-40m),
. *Ireland:* Demersal trawlers (12-24m and 24-40m), Pelagic polyvalent gears (00-12m), Pelagic trawlers (24-40m and >40m) and Beam trawls (24-40m),
. *Netherlands:* Pelagic trawlers (>40m).

The 10 selected fleet segments initially considered account for 56 % of the total value of landing reported specifically from the Celtic Sea (VIIe-k) (Tab. 3.1). Note that the major fleets in term of absolute value of landings are the two added French demersal trawlers, while the Irish demersal trawlers account for 22 % and 12 % (for the 12-24m and 24-40m respectively) of the value of landings specifically reported from the Celtic Sea (which are not representing the whole Celtic Sea landings).

Table 3.1 - Main fleet segments in Celtic Sea in terms of sum landings value registered in the database over the years 2006-2008 in Million Euros

Fleet segment	**Landing Value in the Celtic Sea** *(+french in VII)* **M€ over 2006-08**	**Percentage of the total landing value in VIIe-k over 2006-2008**	**Percentage of the total landing value in VIIe-k + VII french landings over 2006-09**
BEL BeamTrawl 24-40m	11	2.9 %	1.4%
GBR DemTrawlS 24-40m	11,6	3.1 %	1.5%
GBR PotsTraps <10m	11,2	3.0 %	1.5%
GBR BeamTrawl 24-40m	19,8	5.2 %	2.6%
IRL DemTrawlS 12-24m	48,3	12.8 %	6.3%
IRL DemTrawlS 24-40m	42,8	11.3 %	5.6%
IRL Polyvalent <12	20,8	5.5 %	2.7%
IRL PelagTrawlS >40m	14	3.7 %	1.8%
IRL BeamTrawl 24-40m	13,1	3.5 %	1.7%
NDL PelagTrawl >40m	18,9	5.0 %	2.5%
FRA DemTrawlS 12-24m	*313,1*		41.0%
FRA Dredges 12-24m	*71,9*		9.4%
Other fleet segments	167,1	44.1 %	21.9%
Total	**763,7**	**100 %**	**100%**
% of the total landing value for fleets selected		***55.9 %***	***78.1 %***

3.4.2. Economic performance of the selected fleet segments – dependency to the Celtic Sea

This section aims to characterise the economic performances of the main fleets operating in the Celtic Sea, using indicators estimated in the Annual Economic Report (AER, 2010). Such a description takes into account all catches of each fleet, wherever theses catches come from. In a second step, we investigate the contribution of the Celtic Sea to the economic performance of the selected fleet segments, calculating for each fleet segment its global dependency on the Celtic sea, and its specific dependency on the major stocks (see methods in section 2.3). This will allow to identify fleets with the higher proportion of revenues coming from the exploitation of the Celtic Sea, as well as to identify their most economically significant species. A more detailed fleet to fleet description can be found in Appendix 6.

- Indicators of economic performances

Table 3.2 - Summary of the economic indicators of the main fleet segments operating in the Celtic Sea (VIIe-k) following the 2010 Annual Economic Report (AER, 2010) by Anderson and Guillen

	Number of vessels	FTE (Or total employed)	Days at Sea (1000 days)	Volume of landings (1000 tons)	Value of landings (million euros)	Direct subsidies (million euros)	Total Income (million euros)	Average wage per FTE (1000 euros)	GVA (million euros)	Operating cash flow (million euros)	Profit / loss (million euros)	Capital Value (million euros)	ROI (%)	Investments (million euros)
BEL BeamTrawl 24-40m	47	245	9,6	14,4	54,6	0,9	57	67,4	15,7	0				2,2
GBR DemTrawlS 24-40m	109	715	22,3	58,9	105	6	121	37,5	37,9	17,1	10,2	155	0,1	7,4
GBR PotsTraps <10m	1926	1184	277,4	21,4	62,7	1,6	70,6	15,3	46,7	30,2	8,9	111,6	0,1	0,6
GBR BeamTrawl 24-40m	39	132	7,1	8,3	19,8	1,1	21,6	40,2	8,6	4,4	2,9	38,1	0,1	0
NDL PelagTrawl >40m	13	508	3,4	320	142	0	142	0	48,7	12,6	-4,7	229,6	0	1
FRA DemTrawlS 12-18m	196				82,3	1	83,3	37,6	35,8	8,5	-0,5			8,3
FRA DemTrawlS 18-24m	233				153,6	4,7	159,6	37,8	46,6	5,7	-13,5			2,8
FRA Dredges 12-18m	98				40,4	0,7	41	33,0	19,4	4,5	0,1			2,6
FRA Dredges 18-24m	7				0	0,1	0,1	0	0	0,1	0,1			0

In term of vessels number, employment or fishing days at sea, the largest fleet operating in the Celtic Sea is the British pots and traps (<10 m) fleet (Table 3.2). However, looking into the most important fleets in terms of volume and value of landings, we will mention Dutch pelagic trawls (>40m) and French demersal trawlers (18-24m). Looking at the subsidies, it can be observed that French and British demersal trawlers are heavily subsidized compared to the rest. In terms of total fleet income, French demersal trawlers (18-24m) and Dutch pelagic trawls (>40m) are those with higher numbers. In contrast, their average wages are among the lowest. It is important to note that although being subsidized, French demersal trawlers fleet (18-24m) looks to be the less profitable.

Figure 3.10 allows a more straightforward identification of Dutch pelagic trawl (>40m), French demersal trawl (12-18 and 18-24m), British demersal trawl (18-24m) and British pots and traps fleets as the most representative in terms of total income and general value added (GVA). In term of profitability, British fleets (demersal trawl or pots and traps) exhibit large operating cash flow and positive profits, while Dutch pelagic trawlers (>40m) and even more French demersal trawlers (18-24m) appear to be the less profitable fleets, exhibiting negative profits.

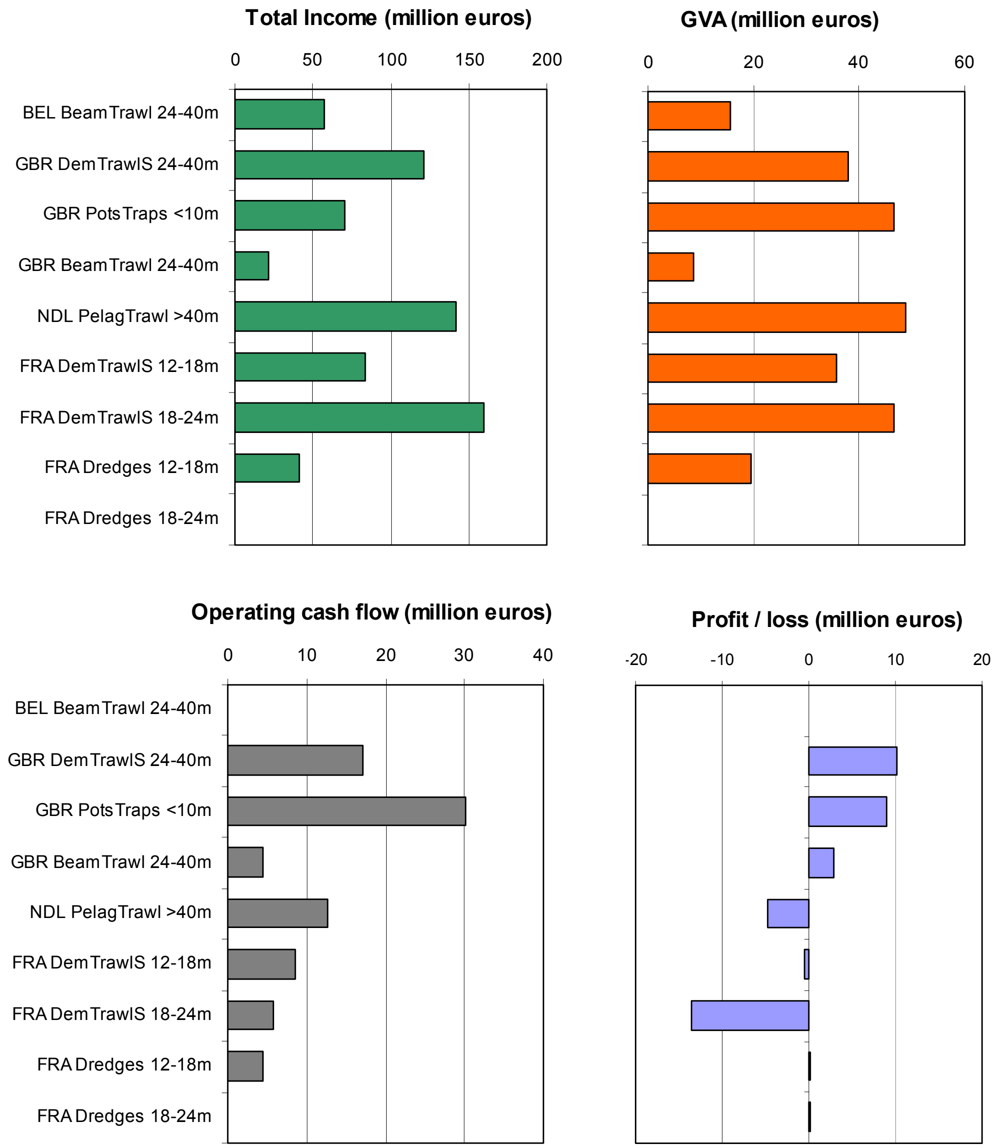


Figure 3.10. Main economic indicators for the selected fleet segments (From AER 2009: note that economic indicators are not available for Irish fleets)

- Dependency to the Celtic Sea stocks

The fleets considered in our analysis operate over the Celtic Sea and other fishing grounds. Among the 12 selected fleets, the fleets whose economic value of landings depend more on their activity in this ecosystem are the French dredges (12-24m) with 100% of their revenues coming from the Celtic Sea (Figure 3.11). Irish and British beam trawls (24-40m) follow with more than 80% of their value of landings depending on Celtic Sea. Irish demersal trawlers of 12-24 m obtain nearly 75% of their value of landings from the CS. French demersal trawls (12-24m) and Irish demersal trawls (24-40m) are the remaining fleets that obtain more than 50% of their total value of landings from the Celtic Sea.

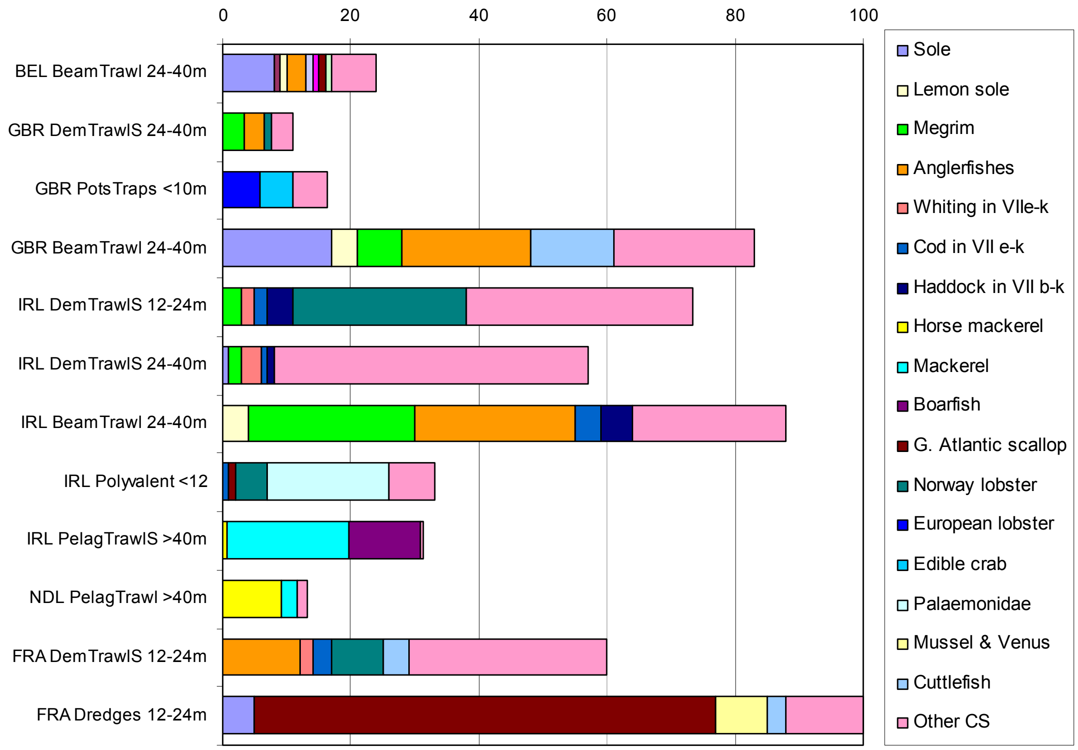


Figure 3.11. Dependency of the selected fleet segments to the Celtic Sea stocks, and to the Celtic Sea as a whole (in % of the total landing value per fleet)

To sum up we could suggest that French dredges (12-24m, mainly operating in the West English Channel), Irish beam and demersal trawls (12-24, 24-40m), British beam (24-40m) and French demersal trawls (12-24m) are the fleets that show the highest economic dependency on the Celtic Sea ecosystem.

Looking at the most relevant CS stocks for those six fleets selected, we identify megrim, anglerfishes and cuttlefish as the most important for the beam trawlers, in term of landed values, while Norway lobster and anglerfishes are the most important for the trawlers and scallops for the dredges.

3.4.3. Index of fleets' impact on the Celtic Sea ecosystem

Aiming at assessing different fleets activity and their interaction with the Celtic Sea ecosystem under an EAF approach, two indices were calculated (see method in §2.3): the partial fishing mortalities applied on the ICES assessed stocks from the Celtic Sea; and the sustainability index per fleet segment according to a comparison between the current state of the stocks they are exploiting and the targets F_{pa}, $F_{0.1}$, B_{pa} and $B_{0.1}$.

- Partial F: contribution to the fishing mortality of assessed stocks

The partial fishing mortality by fleet segment has been estimated for each of the assessed stocks on the basis of the weight of the fleet segment landings on the total landings of that stock in the area. The some of partial F by fleet is a measure of their impact on assessed stocks. It can be consider an indicator of the global impact of the fleet on the Celtic Sea ecosystem.

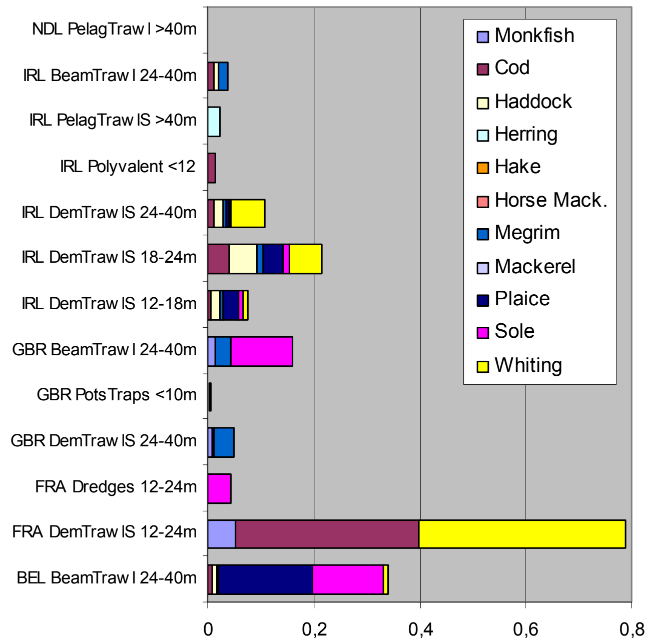


Figure 3.12 – Partial F applied by the selected fleet segments to the stocks assessed by ICES

The French demersal trawl fleet of 12-24m is identified as the fleet segment producing the most significant impact applied to whiting, cod, and monkfish (Fig. 3.12). As a result, this fleet is globally the most impacting one for the resource of the whole Celtic Sea ecosystem. Belgium beam trawlers (24-40m) are mainly impacting plaice and sole, and represent the second fleet segment in term of global impact. The other significant fleet segments are the Irish demersal trawlers and the British beam trawlers. In the opposite, economically important fleets (in term of incomes or cash flow) such as the Dutch pelagic trawlers, the British demersal trawlers and the British vessels using pots and traps appear to have very little impact on the Celtic sea resources. But this can be explained by the fact these fleets are mainly exploiting resources from other ecosystems (and thus are little dependant on the Celtic Sea).

- Sustainability index by fleet segment

The aim of this index is to identify which fleet segments operate over stocks that are under unsustainable harvest levels. On average, Dutch pelagic trawls (>40m) are exploiting stocks that are below their precautionary biomass levels and above their precautionary fishing mortality levels (Fig. 3.13). However, most of the fleets selected in our analysis are operating over stocks currently subject to unsustainable harvest rates, being outside the precautionary limits, either in term of fishing mortality or in term of spawning biomass. Only three fleets segments meet the limits defined by the precautionary approach: the French dredgers (mainly exploiting scallops in the Baie de Saint Brieux), the British vessels using pots and traps, and the Belgium beam trawls (mainly exploiting plaice and sole). Furthermore, none of the fleets considered operates over stocks close to the estimate B0.1 and F0.1 targets.

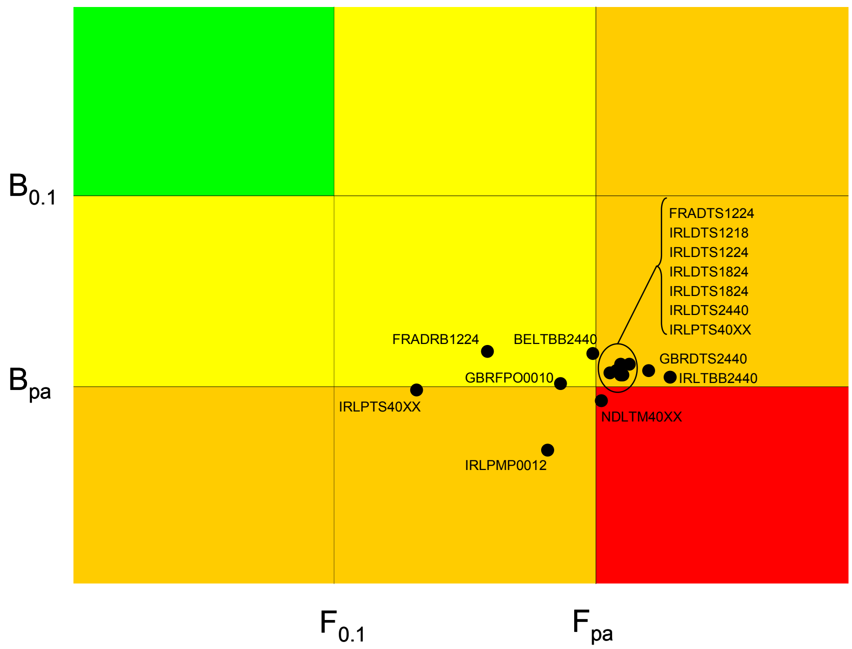


Figure 3.13 – Fleets operating on the Celtic Sea (ICES VII.e-k) in relation to their impact on the main target species. $B_{0.1}$ and $F_{0.1}$ are management targets and Bpa and Fpa are the precautionary limits to biomass and fishing mortality.

- Sustainability index vs economic dependency by fleet segment

Finally, the tradeoffs between the ecosystem impact and the economic relevance of the ecosystem can be analysed for each fleet segment, using the previous indices. As a first test, we show here the tradeoffs between the sustainability index in term of fishing mortality and the dependency measuring the % of value of landings obtained from the exploitation of Celtic Sea waters (Fig. 3.14). This should allow identifying fleets that are more suitable to be regulated following economic and ecological considerations. Those fleets generate the highest ecological impact and are least dependent on the Celtic Sea.

For instance, British demersal trawl fleet (24-40m) is exploiting stocks that are unsustainably harvested and its economic performance does not depend on the Celtic Sea. In contrast, although being also exploiting stocks that are unsustainable exploited, Irish beam trawlers are highly dependant on their operations in the Celtic Sea. As a consequence, their regulation within the Celtic Sea would only respond to ecological concerns but would have strong economic implications.

Other tradeoffs could be analysed, especially between indicators of the economic performances of each fleet (cash flow or profit or GVA) and their ecological impact (total partial mortality or sustainability index).

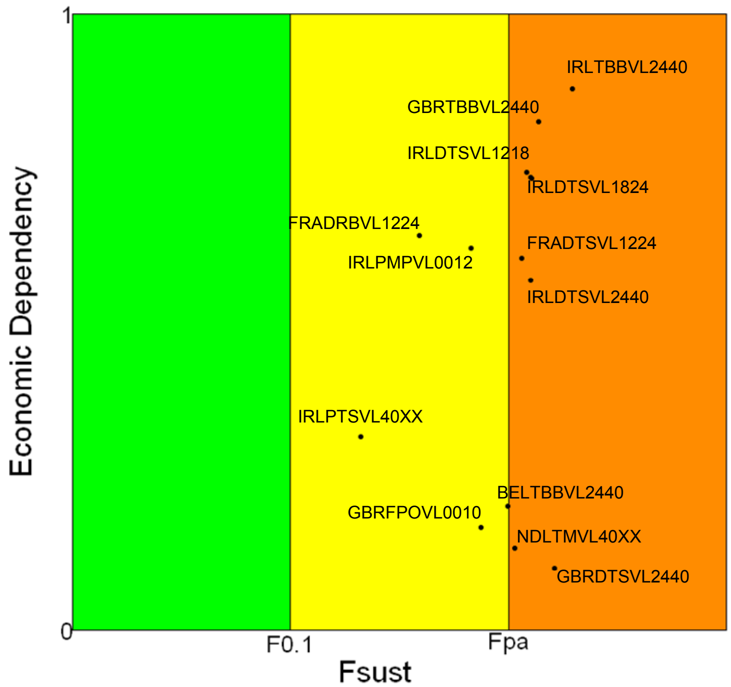


Figure 3.14. Fleets economic dependency on Celtic Sea (Value of landings from CS/Total value of landings) compared to fleets impact on CS ecosystem. As it is observed, some fleets generate a high impact on the ecosystem while obtaining a little fraction of their total landing value (e.g. GBRDTSVL2440).

- Conclusion of the fleet based analysis

Because of problems remaining in the data issued from the DCF (mainly linked to the fact that some countries did not filled the database at the right level of disaggregation), results have to be considered as preliminary and interpreted with great care. At this stage, it can mainly be concluded that, not surprisingly, ecosystem is an adequate level where contrasts between fleet segments can be identified, both in term of their economic performances and of their ecological impact on resources. Some fleet segments appear to exhibit poor economic performances and high ecological impacts, while other may be considered as more virtuous. For instance, we observed that French demersal trawlers seem to be characterised by significant subsidies, negative profits (i.e. losses), strong impact on resources, and bad sustainability index. This is also the case for British demersal trawlers (except regarding profits which are positive for this fleet). In contrast, British vessels using pots and traps seem characterised by a positive profitability, low impact and better index of sustainability. Nevertheless, and once again, these results have to be confirmed by more in depth analyses. They should be a step toward building a fleet based management of fisheries at the scale of the ecosystem.

3.5. Models availability for the Celtic Sea

No available bio-economic model, specifically applied to the Celtic Sea, has been identified by the working group. As for trophodynamic models, two models are currently developed by participants to the working group.

In 2009 Guénette and Gascuel published details of a EwE model for the Bay of Biscay and Celtic Sea (presented at the 25 anniversary Ecopath Conference and at the 2009 annual conference of ICES). The model is primarily focused on 14 industrial species, their prey and predators, but contains in all 38 functional groups. Cod, hake and Norway lobster were separated into juvenile and adult stanzas to account for species size-structured interactions among themselves and the fisheries. Starting from 1980 the model was fitted to biomass and fishery landings datasets using time-series of fishing mortality. The authors also used various climate indices, including the North Atlantic Oscillation index (NAO) and sea surface temperature to modify phytoplankton production and obtain better fits. The model is still in a preliminary phase but it was still able to replicate biomass and catches of most exploited species, from 1980 to 2006. Forcing primary production with the NAO index did not improve the fit to time-series, although discrepancies in biomass and/or landing trends were corrected in some cases. The current version, still in development, focus on cod and hake stanzas, uses times series of zooplankton abundance to account for secondary production.

A completely separate, but more detailed EwE model of the Celtic Sea is currently nearing completion at University of Plymouth (UK) in collaboration with scientists from Cefas, with a technical report on model construction and calibration of time dynamics expected late 2010. This model makes use of locally relevant stomach datasets previously described by Pinnegar et al. (2003) and Trenkel et al. (2005), biomass data from groundfish surveys, and invertebrate data from recent epibenthos and infauna surveys. (e.g. Ellis et al., 2002). Fishing fleets are defined by each country for the principal fishing sectors. The model will be used to investigate the dependence of seabirds and marine mammals on particular forage fish species within the region.

For the moment, these two models provide, or should provide soon, a comprehensive and useful framework to study the main interactions between species and to identify potential ecosystem effects of a change occurring for one specific stock or ecosystem compartment. Nevertheless, the existing models are not specifically devoted, and have not been used yet, to the assessment of fisheries management options, in an ecosystem perspective. As for EcoTroph, mentioned in the terms of reference and whose aim is to build diagnoses of the fishing impact at ecosystem scale (Gascuel and Pauly 2009), it has not been applied to the Celtic Sea. Thus, further work is still needed to evaluate capability of trophodynamic approaches within the scientific advice process. Participants to the working group suggest that a specific workshop could be organized to evaluate more precisely the ability of such kind of models to draw general diagnosis on fishing impact and ecosystem health, or to compare the ecosystem effects of various management options.

3.6. Summary of the Celtic Sea results - Conclusion

The Celtic Sea has been intensively fished for decades. Over the last 15 or 20 years, total landings are sharply declining, while small pelagics, molluscs and crustaceans represent an increasing part of the catch. Although the fishing pressure seems to decrease since about 10 years, it is still very high and stocks remain in a bad shape, with biomass very close to the Bpa limit. For the last available year (depending on stocks) 6 among the 9 stocks assessed by ICES in this area were outside of the limits defined by the precautionary approach, all of them being overexploited (with F>F0.1).

The working group was not able to identify any previous study which would have estimated values of the ecosystem indicators from the reference list, specifically for the Celtic Sea ecosystem. Due to time constraints, such calculations can neither took place during the meeting. Nevertheless, as a very preliminary approach, the mean trophic level of catch was estimated. A very significant decrease in this indicator is observed over the last 20 years.

Fleet based analysis was unfortunately based on an incomplete database and has to be considered mainly a methodological test. It constitutes a first attempt to identify contrast between fleet segments operating in the Celtic Sea, in term of economical performance and ecological impact. Even if more work is obviously required, the test can be considered a success. Indicators show, for instance, that some fleet segments receiving higher subsidies than others exhibit negative profits and have severe impacts on the resource, while others appear more virtuous. Such type of identification constitutes a step toward a fleet based management within the ecosystem and strengthens the argument that subsidies don’t solve the short term economic problems of industry while probably increasing pressure on ecosystems. The benefit of developing positive or negative economic incentives in order to favor or reduce some fleet segments or to encourage fleets to improve their fishing practices could also be highlighted

No operational model, able to simulate various fishing management option was identified by the working group. Two trophodynamic models are presently under construction, but more work is still needed before they could be used in an EAFM perspective. Multispecies bio-economic models should be additionally considered.

4. North Sea results

4.1. Trends in catches and fishing effort

The North Sea supplies approximately two million tonnes of fish each year from the three main sectors; industrial, pelagic and demersal, in order of size. Denmark, UK, Netherlands and Norway are responsible for the majority of landings although Germany, Belgium and France all have vessels that operate in the North Sea.

Demersal fisheries target roundfish species such as cod (*Gadus morhua*), haddock (*Gadus aeglefinus*) and whiting (*Gadus merlangus*) in addition to flatfish species such as plaice (*Pleuronectes platessa*), sole (*Solea solea*) and a fishery for saithe (*Pollachius virens*). Pelagic fisheries target herring (*Clupea harenguss*) and mackerel (*Scomber scomber*) and the industrial fisheries target sandeel (*Ammodytes spp*), Norway pout (*Trisopterus esmarkii*) and sprat (*Sprattus sprattus*). There are also important crustacean fisheries for nephrops (*Nephrops norvegicus*), pink shrimp (*Panadalus borealis*), brown shrimp (*Crangon crangon*) and brown crab (*Cancer pagurus*). Table 4.1 provides a breakdown of contribution to total landings, averaged over 10 years.

Table 4.1. Top 20 species in North Sea, showing average catch 1997-2007 and proportion of total North Sea landing. Name labels used in the North Sea ecopath model (Mackinson and Daskalov 2007, Mackinson et al. 2009) are given for information relating to ToR 5.

	Species	**North Sea Ecopath model Functional Group**	**Average landings (t) 1997-2007**	**Proportion of total landings**
1	Sandeels(=Sandlances) nei	Sandeels	614901	29%
2	Atlantic herring	Herring (adult)	311026	15%
3	Atlantic mackerel	Mackerel	226455	11%
4	European sprat	Sprat	175021	8%
5	Blue whiting(=Poutassou)	Blue whiting	121875	6%
6	Saithe(=Pollock)	Saithe (adult)	93840	4%
7	Norway pout	Norway pout	69363	3%
8	European plaice	Plaice	67759	3%
9	Blue mussel	Sessile epifauna	67605	3%
10	Atlantic cod	Cod (adult)	50337	2%
11	Haddock	Haddock (adult)	48937	2%
12	Atlantic horse mackerel	Horse mackerel	48067	2%
13	Common shrimp	Shrimp	35436	2%
14	Common edible cockle	Infaunal macrobenthos	26558	1%
15	Whiting	Whiting (adult)	17953	1%
16	Norway lobster	Nephrops	17617	1%
17	Common sole	Sole	16985	1%
18	Edible crab	Large crabs	9707	0.5%
19	Common dab	Dab	9637	0.5%
20	OTHER (sum)		150652	7%

Industrial and pelagic species combined have accounted for an increasing proportion of the landings, while landings of demersal stocks have declined in line with falling stock sizes and regulated reductions in total allowable catches (Fig. 4.1). Total catches peaked around 3.5 million tonnes in 1974-76 and remained higher than 3 million tonnes from 1966 to 1977. Since this period of time, despite increasing landing of some stocks like sandeels, the total catches exhibit a declining trend, with an accelerating decrease since the 1990s.

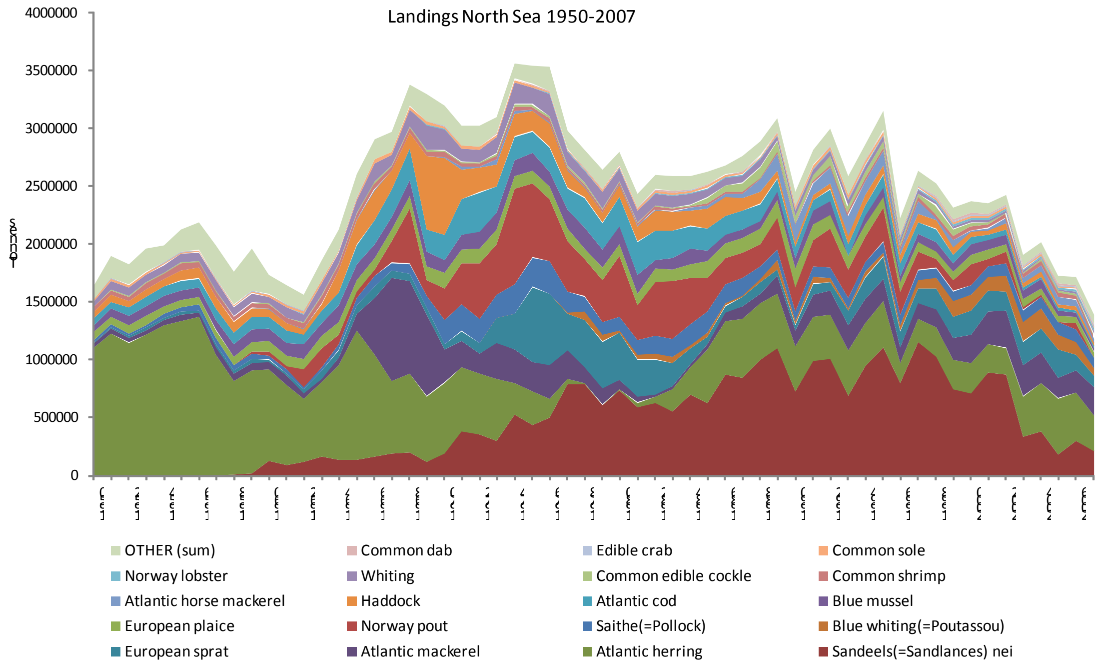


Figure 4.1. North Sea landings 1950-2008 from ICES Statlant

Total catches of North Sea fish since the turn of the century provide the broader context for the declines seen since the mid 1990s (Fig. 4.2). Some stocks, especially herring and secondarily cod, haddock and plaice, were already intensively fished in the late 19th century, providing at that time more than 1 million tonnes of landings per year. Landing of these species, and the total landings as well, regularly increased (except of course during the two world wars) reaching more than 2 millions tons in 1956. Things radically changed in the 1960s. While herring accounted for a large majority of catch before, this fishery collapsed and a much wider range of the ecosystem became exploited. Total landings strongly increased until the mid 1970s, before decreasing. Current reported landings stand at around 1.4 million tonnes.

It should be noticed that these statistics certainly underestimate total removals because of the prevalence of discarding and unreported landings.

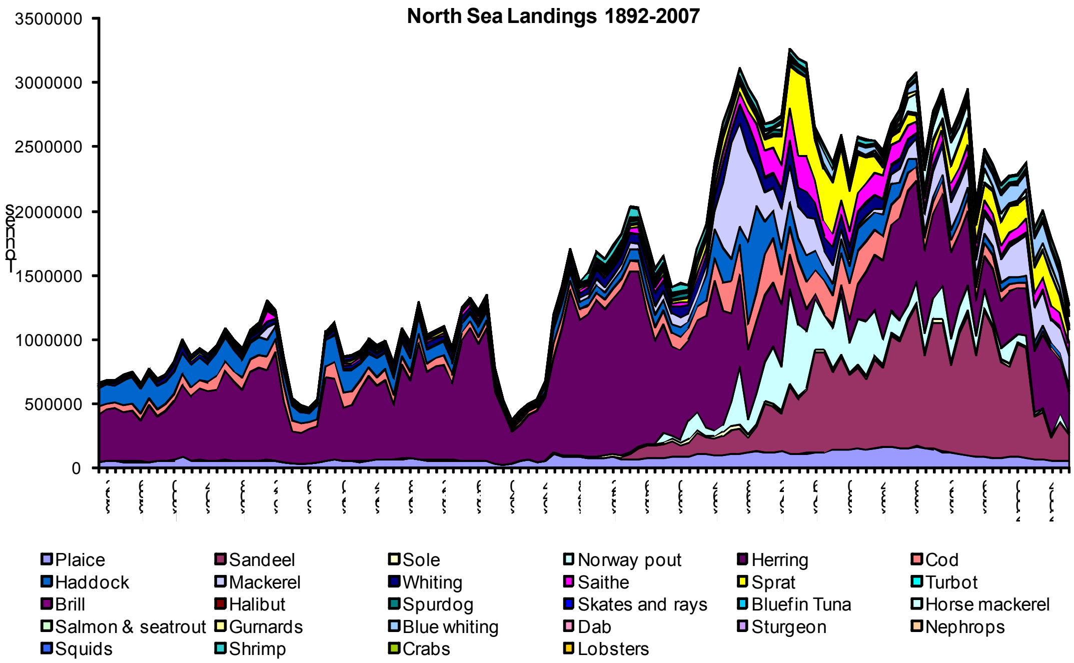


Figure 4.2. North Sea landings 1892-2007 (Data compiled by Mackinson and Pinnegar, Cefas)

Trends in effort of the tuning fleets (Fig. 4.3), based on ICES WG assessment reports and using fleet categories from the Data Collection Framework (Table 4.2), are consistent with that published in STECF SGRST report 2009. In recent years, assessment procedures for some stocks have moved away from using the effort of commercial fleets to tune stock assessments, in favour of using fisheries independent survey data. The outcome of this is that the time series are no longer routinely reported in ICES WG assessment reports and must be sought directly from sources in each country. Note, for example, that effort data are not reported for fleets targeting Nephrops and Shrimp since 2003 and Scottish Trawls since 2004.

Table 4.2: Sources for effort data, categorised in to DCF fleets

DCF Fleet	Period available	Source and notes
Demersal trawl & seine	1978-2008	(WGNNSK08, 2008), including fleets SCOSEI_IV, SCOLTR_IV, ENGTRL_IV, ENGSEI_IV, FRATRB_IV, FRATRO_IV, NORTRL_IV, GER_OTB_IV
Beam trawl	1979-2007	(WGNNSK08, 2008), including fleets NL_BT_EFF,UK_BT_EFF
Pelagic trawl & seine	1987-2006	(WGNNSK08, 2008) fleet NOR_DEN_NPOUT_EFF
Nephrops trawl	1981-2004	(WGNSSK06, 2006), summed over Nephrops functional units
Shrimp trawl	1984-2003	(WGPAN, 2005), Pandulus – total international effort in ICES div IV.

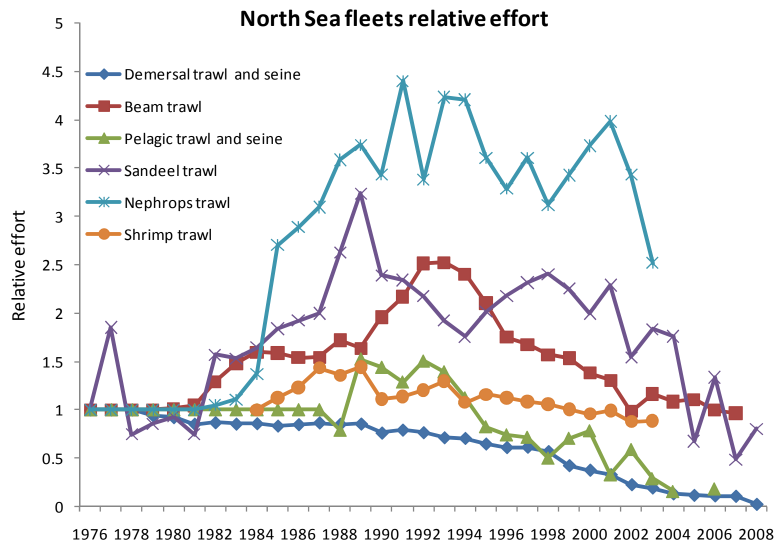


Figure 4.3. Relative effort of principal North Sea fleets since 1976. Note: see Table 4.2 for description of aggregation of fleet categories used.

4.2. Stocks synthesis

In this section we present ecosystem indices that capture the trends for several fish stocks at the same time by pooling the data for each stock. Four indices are presented: total SSB, total catches, mean F and recruitment. However, because of differences in the time periods of available data, two assemblages of stocks have been used, one covering 6 stocks from 1967-2008, the other 14 stocks from 1984-2008 (see Table 4.3).

Additionally to the 14 stocks presented in this table, sprat has also been assessed since 1987, but some methodological issues highlighted recently have not been resolved yet and this stock is no longer assessed. Due to the lack of recent information, sprat is not included in the following indicators despite its importance in the North Sea ecosystem. Moreover, blue whiting is also an assessed stock but with a broad distribution. Because the proportion of catches of blue whiting coming from the North Sea is lower than 3%, this stock is not included in the calculation of the following indicators in order to avoid a too strong influence of this stock which actually occurs only in a small area of the North Sea ecosystem.

Table 4.3: List of stocks used for the computation of total SSB, total catches, mean F and recruitment index according to the period considered.

Stock assemblage	**Period considered**	**Stocks included**
6-stocks Index	1967-2008	Cod in Sub-area IV, Divison VIId & Division IIIa (Skagerrak) Haddock in Sub-area IV (North Sea) and Division IIIa Herring in Sub-area IV, Divisions VIId & IIIa (autumn-spawn.) Plaice Sub-area IV (North Sea) Saithe in Sub-area IV, Division IIIa (Skagerrak) & Sub-area VI Sole in Sub-area IV (North Sea)
14-stocks Index	1984-2007	Cod in Sub-area IV, Divison VIId & Division IIIa (Skagerrak) Haddock in Sub-area IV (North Sea) and Division IIIa Herring in Sub-area IV, Divisions VIId & IIIa (autumn-spawn.) Plaice Sub-area IV (North Sea) Saithe in Sub-area IV, Division IIIa (Skagerrak) & Sub-area VI

		Sole in Sub-area IV (North Sea) Mackerel (combined Southern, Western & N.Sea spawn.comp.) Sandeel in Sub-area IV Sole in Division VIId (Eastern Channel) Sole in Division IIIa Whiting Sub-area IV (North Sea) & Division VIId (E.Channel) Plaice in Division VIId (Eastern Channel) Mackerel (combined Southern, Western & N.Sea spawn.comp.) Norway Pout in Fishing Area IV and IIIa

The 6 and 14 stocks used to compute the indexes represent respectively around 50% and 80% of the total landings during the considered periods (figure 4.4). In 1982 the proportion of landings coming from assessed stocks goes from 35 to 80%; this threshold is mainly due to the beginning of the assessment of sandeels, which represent around 30% of the landings (see part 4.1). Sole in the eastern Channel, horse mackerel and Norway pout also started to be evaluated during this period. When considering the ecosystem after 1983, the set of the 14 stocks listed in table 4.3 is considered highly representative of the North Sea ecosystem. They are part of the 20 most important species in landings (see part 4.1), the other important species being sprat, blue whiting, blue mussel, common shrimp, common edible cockle, Norway lobster, edible crab and common dab. We can note that among these species, some are assessed in other ecosystems but not in the North Sea and some may be assessed locally but not by ICES. The decrease of the percentage of assessed species in the last year (2007) is due to the stop of sprat evaluation. The importance of other non-assessed species that are seemingly abundant, but infrequently landed should not be overlooked. Such species include gurnards, and small demersal fish such as weaver fish, bib, dragonets, solenettes etc.

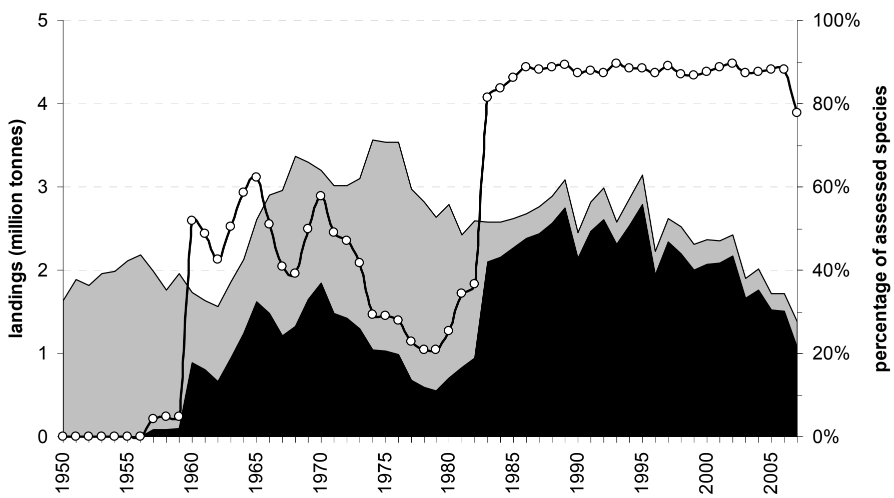


Figure 4.4 - Proportion of the total landings of assessed species (black area) over the total landings in the North Sea (grey area), in absolute value (left y-axis) and in percentage (curve). For this figure sprat and blue whiting have been included.

- Trends in Ytot, SSBtot, Rmean, Fmean

Note: The following indicators (total catches, total spawning stock biomass, recruitment index, mean fishing mortality) have been computed for the two stocks assemblages presented in table 4.3, as they are the only stocks for which sufficient data was available.

With up to 2 millions tons in 1970, the total catches of assessed species in the North Sea have been decreasing until 1978 when they started to increase again (figure 4.5). When considering more stocks (14-stocks index) the total catches appear stable for the period 1984-1995, at a value of 3.5 millions tons, before an abrupt decrease toward a current value of 1.6 millions tons. Even if the absolute value varies between the total catches calculated for the two periods, their trends are similar and show a general decrease of the total amount of catches in the North Sea by a factor 2 since the beginning of the 1990s.

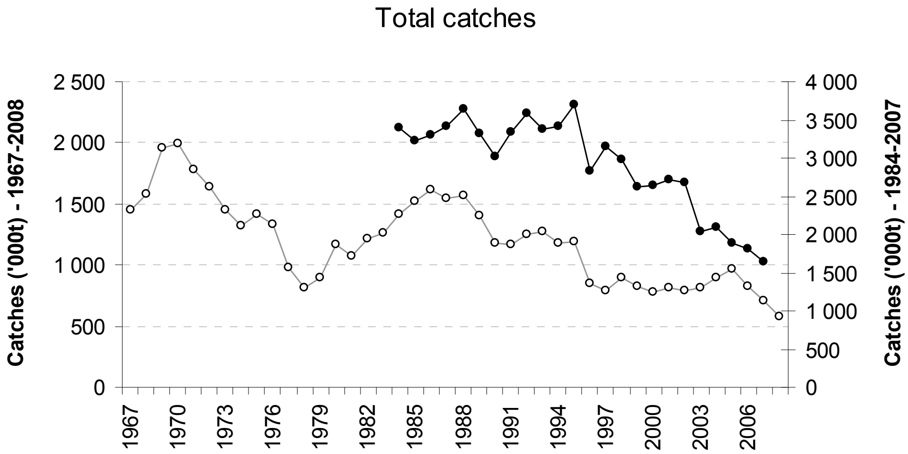


Figure 4.5: Total catches of the assessed species of the North Sea for two periods. See table 4.3 for the list of stocks included in the total catches. Open circles and solid circles refer to the 6 stocks and 14 stocks assemblages, respectively (see Table 4.3).

The total spawning stock biomass has displayed decadal oscillations since 1967 (Figure 4.6). When looking at the longest time series, it seems that the total SSB has increased since 1995. However, the index involving more stocks (and which represents a large majority of the total biomass of commercial fish) shows a different pattern, being stable since 1995 at a value just below 8 millions tons. Thus, whereas some stocks (the ones assessed for a long time) have seen their SSB increased, the overall spawning biomass of the commercial fish community in the North Sea has not recover for the last 15 years.

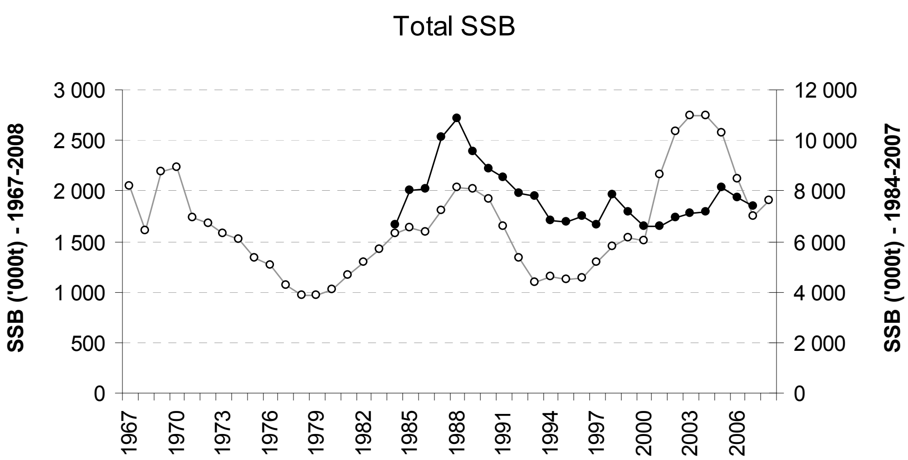


Figure 4.6: Total spawning stock biomass of the assessed species of the North Sea for two periods. See table 4.3 for the list of stocks included in the total SSB. Open circles and solid circles refer to the 6 stocks and 14 stocks assemblages, respectively (see Table 4.3).

The mean fishing mortality of the assessed stocks shows two periods of increase: from 1967 to 1976 and from 1981 to 1986 (figure 4.7). Since 1986, the mean fishing mortality has decreased by a factor 2. For this indicator, the 6-stocks index and the 14-stocks index are similar, both in pattern and in value.

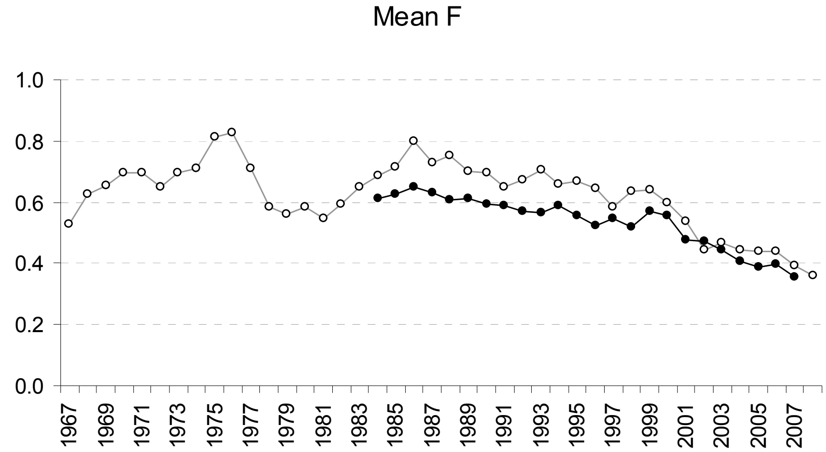


Figure 4.7: Mean fishing mortality of the assessed species of the North Sea for two periods. See table 4.3 for the list of stocks included in mean F. Open circles and solid circles refer to the 6 stocks and 14 stocks assemblages, respectively (see Table 4.3).

The recruitment index has been quite constant despite variability during the period 1967-1985 (figure 4.8). The recruitment during the period 1987-2002 is also stable, but at a lower value than the previous years. Finally, from 2002 until now the global recruitment has been decreasing and is currently at the lowest level observed since 1967. The particularly high recruitment index value in 1967 and 1982 are due to high recruitment of haddock and horse mackerel respectively.

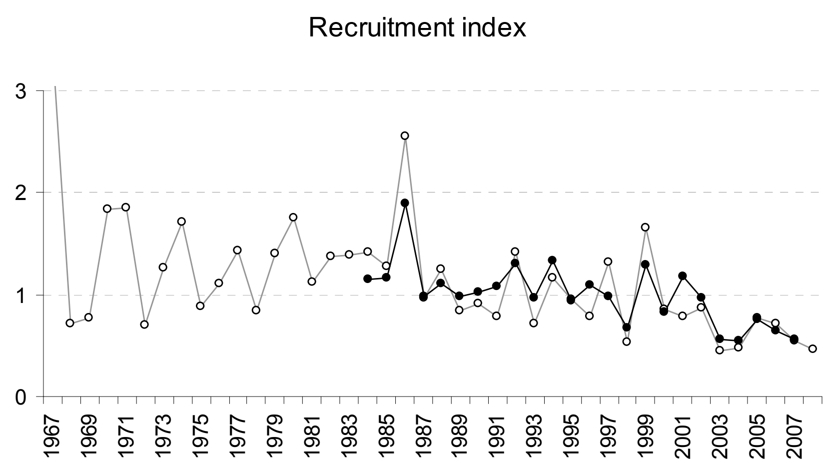


Figure 4.8: Recruitment index of the assessed species of the North Sea for two periods. See table 4.3 for the list of stocks included in this recruitment index. Open circles and solid circles refer to the 6 stocks and 14 stocks assemblages, respectively (see Table 4.3).

- Stock dependency to the ecosystem

In the North Sea, stocks are well defined and their spatial distribution is often within the ecosystem boundaries. However, few stocks occur in several ecosystems either due to broad migrations or a poor definition of stocks boundaries for some species. In the North Sea, it is particularly the case for the mackerel and blue whiting.

. Mackerel is assessed at a large spatial scale, the northeast Atlantic. It covers the following sub-divisions: IIa, IIIa,b,d, IV, Va, Vb, VI, VII, VIIIa,b,c,d,e, IXa, XII, XIV. Catch per division is available at a broad scale (Figure 4.9) but do not provide enough detail for the proportion of the stock present in the studied ecosystem to be derived (areas IIIa, IVa-c and VIId). Moreover, this figure illustrates the variability over the years of the proportion of mackerel caught in the North Sea over the total catch of mackerel (from 5% up to 57%). Even if the assessment is made for a broader area than the North Sea ecosystem, and in the absence of finer data, we used information available for the whole stock.

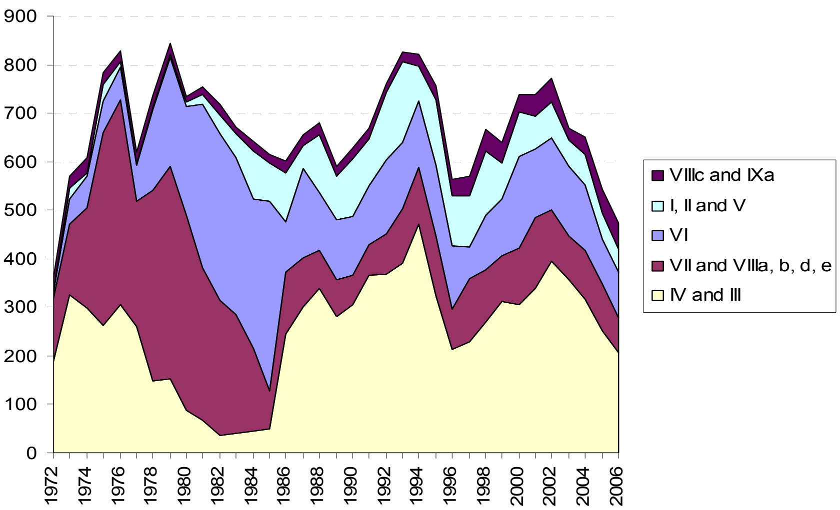


Figure 4.9: Catch of mackerel per division from 1972 to 2006.

. Blue whiting: The stock of blue whiting occurs in the northern part of the North Sea, and therefore the North Sea ecosystem only comprises the southern part of the stock. In 2008, the landings of blue whiting coming from the North Sea represented only 2.89% of the total landings of the blue whiting stock. Due to the lack of data preventing us to calculate the ratio over a longer time series, we cannot estimate a realistic proportion of the stock being present in the North Sea. However, when such a ratio will be available, this stock should be added to the previous indicators (weighted by its ratio of presence in the North Sea).

- Graph on the current status of stocks

When enough data was available, the current status of each stock (F*, B*) was assessed and compared to the reference points: Fpa and Bpa, and $F_{0.1}$ and $B_{0.1}$ the latter two being considered as proxy for F_{MSY} and B_{MSY} respectively. Their position according to overfishing or safe areas is illustrated in figure 4.10. Cod is currently in a bad position, with F and B being beyond their precautionary levels. Herring also appears to be in a poor state, with its biomass well below Bpa. On the other hand, blue whiting displays a high biomass, even above $B_{0.1}$. But as stated before, less than 3% of this stock is present in the North Sea.

Generally, it appears than none of the assessed stocks can be considered in good conditions in relation to the MSY approach (i.e. in the green area on the figure), and 40% of them are in the unsustainable zones, as defined by their precautionary levels.

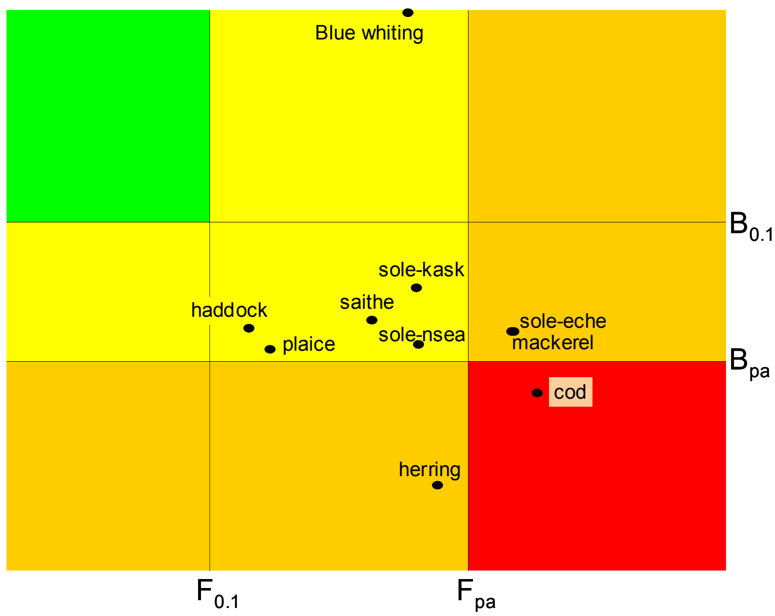


Figure 4.10: Current situation of several stocks of the North Sea (during 2008 or 2007 depending on available information) compared to the precautionary approach (pa) and MSY (approximated by 0.1) reference points.

- Trajectories

The mean trajectory of the state of the set of assessed stocks is represented in the figure 4.11. The longer time series, starting in 1967 already in the overfished zone, shows a strong degradation of the exploited ecosystem state over the years with F and B values being for a long period in the "high risk" area. From the 1980s the fishing mortality has been decreasing but remains higher than Fpa and the biomass has been improving a little but still fluctuates around Bpa. From an exploited situation in 1967, the ecosystem has been ever more exploited in the following years, and even if some effort have been made to manage the stocks sustainably, the ecosystem has not recovered a healthy state nor it has recovered it previous mid-1960s state.

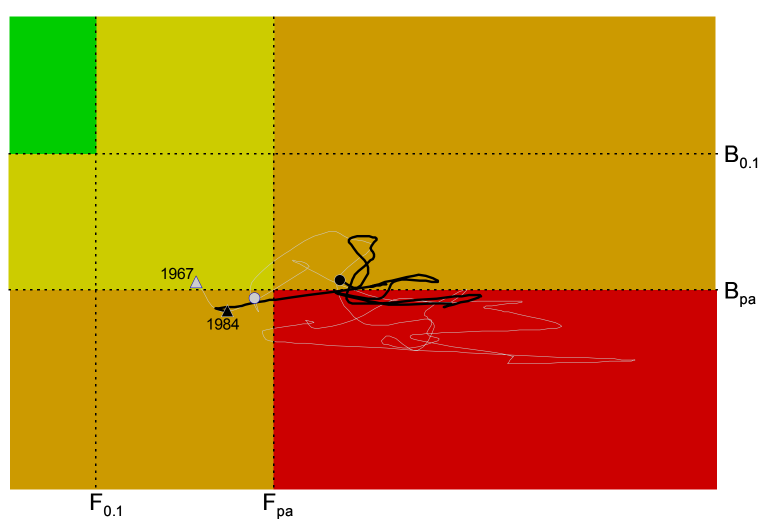


Figure 4.11: Mean situation of the North Sea, computed from the stocks displayed in figure 4.10. Light curve goes from 1967 (white triangle) to 2008 (white circle) and involve the following stocks: cod, haddock, herring, plaice-nsea, saithe and sole-nsea. Dark thick curve goes from 1984 (black triangle) to 2007 (black circle) and involve the previous stocks and mackerel, sole-eche and sole-kask.

- Conclusion of the stock synthesis

The previous indicators indicate a fluctuating state of the North Sea ecosystem from 1967, period at which the ecosystem was already experiencing high exploitation rates with the highest landings observed since 1950 (Fig. 4.4). From 1985, the mean fishing mortality has been constantly decreasing, leading to lower total catches as well. However, the total spawning stock biomass has not changed, indicating a lack of recovery of the ecosystem. It is worth noting that during the last year the recruitment index has been poor, probably preventing the SSB from taking advantage of the reduced fishing mortality. However, as a certain delay is to be taken into account between the recruitment and its potential effects on the SSB, we can conclude that the decrease of mean fishing mortality has probably not been strong enough and/or long enough to allow the recovery of the North Sea ecosystem from a strongly exploited state. Moreover, when looking at the current status of the exploited ecosystem, it is clear that the fishing mortality is higher than the one advised by the MSY approach and thus should be reduced if we want to see an improvement in the biomass of the main stocks. In its current situation, the North Sea ecosystem cannot be qualified as being exploited sustainably.

4.3. Ecosystem indicators

This section contains the "results of some of the ecosystem indicators suggested by (EC 2008): Conservation status of fish species, Proportion of large fish, Mean maximum length of fishes, Size at maturation of exploited fish species, and Spatial distribution of fishing activities.

- Conservation status of fish species

Two indicators for the conservation status of fish species were calculated: CSFa is an indicator of the biodiversity of vulnerable fish species with reference to the IUCN threat criteria that responds to changes in the proportion of contributing species that are threatened and CSFb an indicator of the biodiversity of vulnerable fish species that tracks year-to-year changes in the abundance of contributing species.

Four versions of the CSFa indicator were calculated (Figure 4.12), but SGMOS considered CSFa based on the 5 year list and 3 year average as the most appropriate and also appears to be the most precautionary. This indicator shows that the conservation status is deteriorating (as the value of the indicator is increasing) but the indicator is still below the limit reference level of 1, adopted by (EC 2008) and equating to all the species in the list being considered 'vulnerable'. It should be noted, however, that as this is the average IUCN threat status of species in the list, a single species could become 'critically endangered' or even lost from the system without the indicator value reaching the limit threshold.

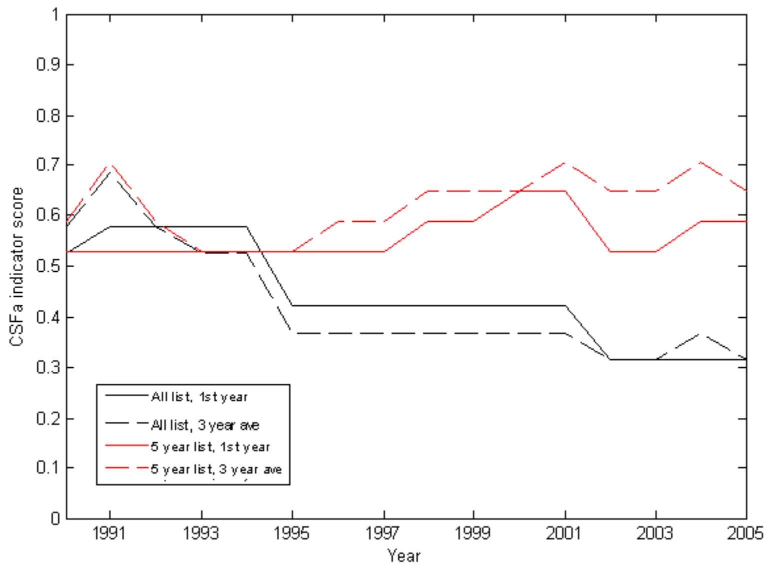


Figure 4.12: CSFa indicator values calculated with the full and 5 year species lists, and using either the first year or average of the first three years as the reference period. From the MEFEPO project (Le Quesne 2010).

CSFb is a conservation status indicator that reports the average abundance of the large fish community on an annual basis in relation to reference period. The reference period is the average abundance over the first three years of the time series. The CSFb indicator was calculated using both the full species list and the 5 year species list (Figure 4.13). The indicator considered most appropriate by SGMOS was based on the 5 year species list showing an approximately 20% decline in the average biomass of large vulnerable fish compared to the reference period and thus a deteriorating trend.

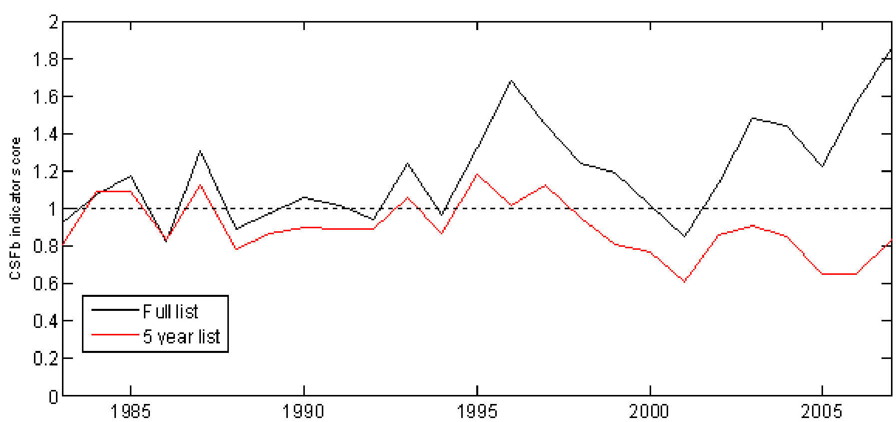


Figure 4.13: CSFb indicator values calculated with the full and 5 year species lists. The dashed line is a reference line with a value of 1. From the MEFEPO project (Le Quesne 2010).

- Proportion of large fish

The proportion of large fish indicator based on two monitoring programs (IBTS and SAGFS) is shown in figure 4.14 showing the indicator reached its lowest point in 2001, falling to a value of 0.05, but has subsequently recovered in 2008 to a value of 0.22. The indicator, however, is still below the target level of 0.3.

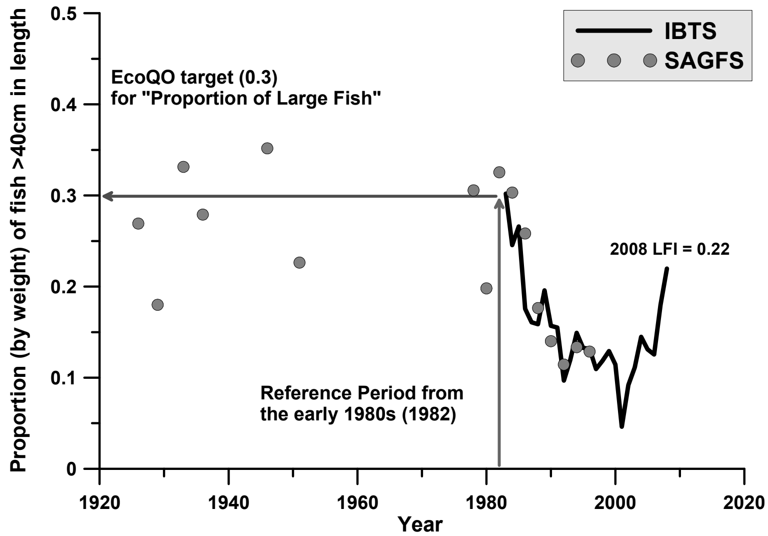


Figure 4.14. Variation in the LFI, based on the Q1 IBTS. Stock assessments in the early 1980s suggested that stocks were not being overexploited at that time. The early 1980s were therefore considered to be a "reference" period, and the LFI recorded at that time deemed to be an appropriate level for managers to aspire to. The EcoQO is therefore 0.3 (see discussion in Appendix 3). The SAGFS LFI tracks the IBTS Q1 index remarkably well over the period that the two surveys coincided, while the earlier index values varied around 0.29.

- Mean maximum length of fishes

The indicator trend was estimated 5 for the North Sea and for the Kattegat and Skagerrak separately (Fig. 4.1). The North Sea figure shows two peaks, one in the late eighties, the other in the early 2000s but no clear trend over time. In contrast the figure for the Kattegat and Skagerrak does show a deteriorating trend indicating a decline in K-selected (large maximum size, slow maturing) species.

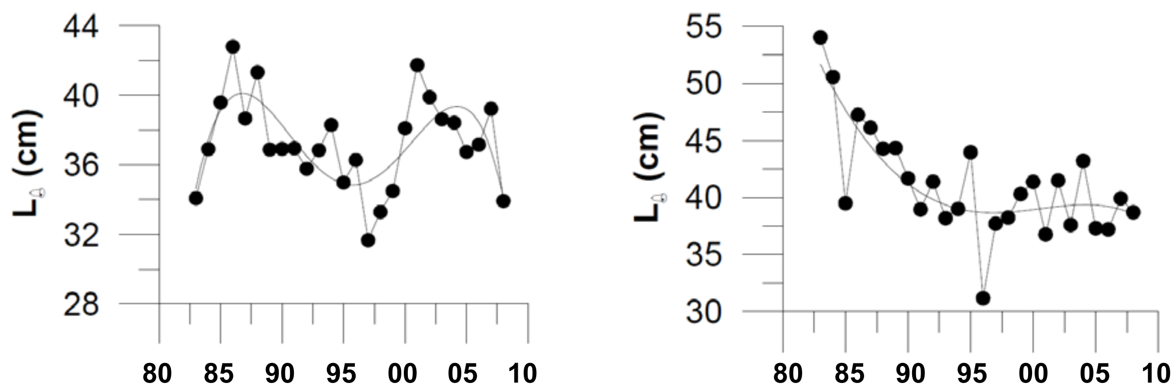


Figure 4.15. Time-series of the Mean maximum length indicator (MMLI) applied to the IBTS Q1 groundfish survey data from 1983 (the start of consistent Q1 IBTS) up to 2008, for the North Sea (left) and for the Kattegat and Skagerrak (Right). Results based on (ICES 2009).

- Size at maturation of exploited fish species

This indicator is not calculated on a regular basis but two studies exist that show for the North Sea the PMRNI over time for plaice (*Pleuronectes platessa*) (Grift et al. 2003) and sole (*Solea vulgaris*) (Mollet et al. 2007).

The PMRNI for plaice (Fig. 4.16) and sole (Fig. 4.17) both show that the reaction norm for age and length at maturation has indeed significantly shifted towards younger age and smaller length. This is attributed to intensive exploitation which may have caused evolutionary changes in the age and length at maturation of these species.

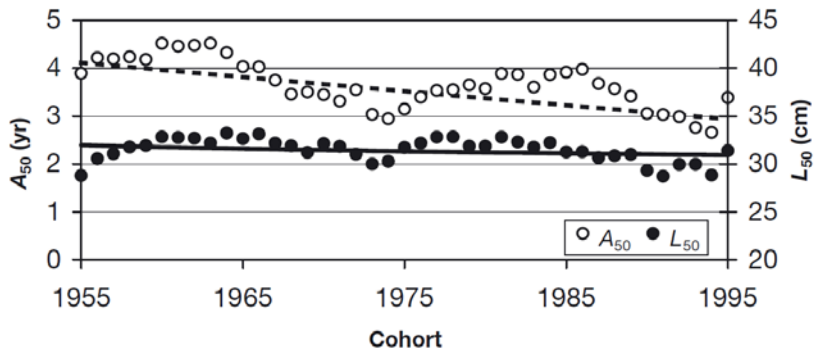


Fig. 4.16. PMRNI for plaice (*Pleuronectes platessa*): trends in the age (A50) and length (L50) at which 50% of fish are mature in each cohort. Data from logistic models with cohort either as a factor (open and filled circles) or as a variate (dashed and continuous lines). In both cases, the decline of A50 and L50 with time is significant ($p < 0.0001$)

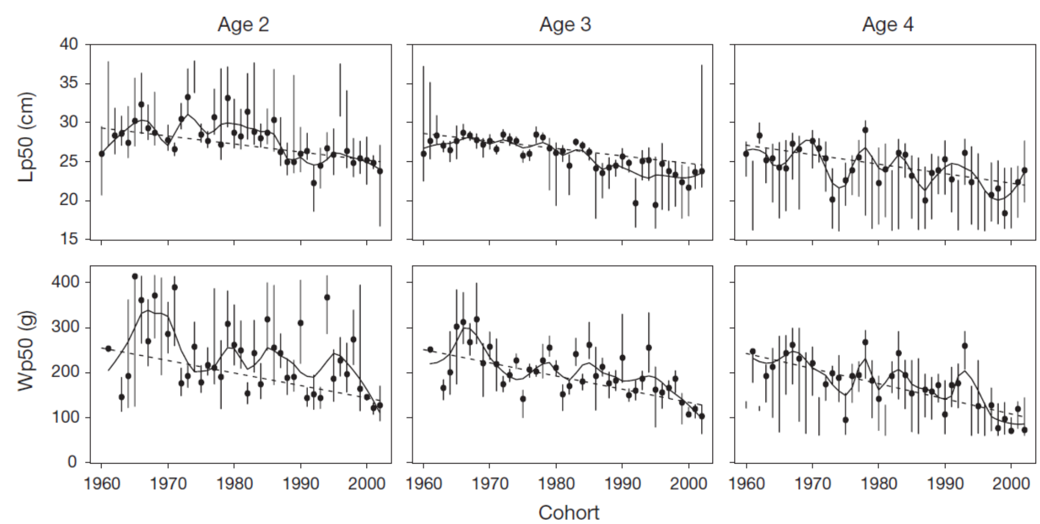


Fig. 4.17. PMRNI for North Sea sole (*Solea vulgaris*) reaction norm midpoints Lp50 and Wp50 over time (dots), bootstrapped 95% percentiles (vertical bars), trend regression weighted by the inverse bootstrap variances (---) and fit with a non-parametric smoother. All trends are significant on a level of $\alpha = 10^{-4}$

- Spatial distribution of fishing activities

The proportion of area not trawled, by depth and habitat types, was calculated from the map of effort by mobile bottom gears using available VMS data (See Appendix 3). The calculation of the percentage of area not impacted by mobile bottom gear per combined depth band and sediment type shows there are considerable differences between habitats/depth bands ranging from 0% to 49% unfished in 2007. As there were no time-series available or reference levels known we can not draw any conclusions on the (change in) state of the ecosystem from these results.

- Conclusion

All ecosystem indicators are reflecting the strong fishing pressure exerted on the North Sea ecosystem. The proportion of large fish is the only one which is improving during the last years, but this occurs after declining for the past twenty years, and the target value is still not met. At the same time: the proportion of endanger species is increasing, the mean maximum length is decreasing in the Kattegat and Skagerrak, and evolutionary changes towards younger age and smaller length at maturation are observed for the studied species.
These ecosystem indicators are in accordance with results based on the stocks synthesis. Even if the fishing pressure has been reduced in the very last years, the ecosystem health is at least not recovering and could be still deteriorating.

4.4. Fleet-based synthesis

- Landing value per country and selection of fleet segment

The North Sea area considered in this section includes the ICES Divisions IIIa, IVa-c and VIId. Landings by non-EU countries are not available at DCF level and not included in the analysis. Note also that France did not provide data for North Sea for year 2008.

The UK fleet represents the most important EU fleet in the North Sea in terms of revenues (Fig. 4.18). This amount to almost 400 million Euro, which is equivalent to 39% of the total revenue obtained in the area by EU fleets. Other important countries are Germany, whose fleet produces more than a quarter of total revenues, and Denmark with 18% of the total.

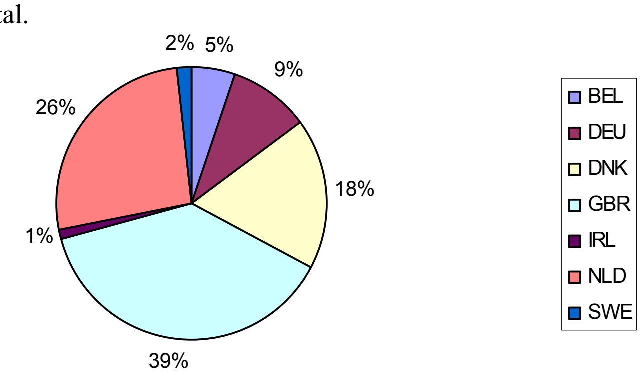


Figure 4.18 – EU landing value by country in the North Sea (Source: DCF data 2008)

Based on the DCF fleet segmentation, 83 European fleets are active in the North Sea. The ten most important fleets in terms of revenues obtained by the exploitation of the North Sea stocks were selected for the present analysis (Table 4.4). The landings value of these first 10 fleet segments, amounting to 634 million Euro, represents 61% of the total landings value obtained in the area by EU registered fleets, which is estimated in 1,030 million Euro in 2008. The main fleet segments include a fleet from Belgium, two from Denmark, four fleet segments from UK and three from the Netherlands. The highest level of revenues from North Sea landings is obtained by beam trawlers over 40m from the Netherlands with 114 million Euros in 2008. This fleet segment represents more than 10% of the total revenues registered in the area in 2008.

Table 4.4 – Most relevant fleet segments in the North Sea in terms of landings value

COUNTRY	GEAR	LENGTH	Total landing value (Million Euro)	%
BEL	TBB	24-40 m	36.2	4%
DNK	TM	24-40 m	37.4	4%
DNK	TM	> 40 m	82.2	8%
GBR	DTS	18-24 m	89.1	9%
GBR	DTS	24-40 m	82.4	8%
GBR	FPO	< 10 m	29.8	3%
GBR	PS	> 40 m	66.4	6%
NLD	TBB	18- 24 m	58.8	6%
NLD	TBB	> 40 m	113.9	11%
NLD	TM	> 40 m	37.4	4%
Other fleet segments			397.9	39%
TOTAL			1031.4	100%

- Economic performance of the main fleets operating in the North Sea

Economic indicators reported in the AER 2010 for the main EU fleet segments operating in the North Sea allow for a comparison among the selected fleet segments (Table 4.5 and Fig.4.19).

Table 4.5 - Economic indicators for the ten most important fleet segments in the NS (Source: AER 2010; data 2008)

	Number of vessels	FTE (Or total employed)	Days at Sea (1000 days)	Volume of landings (1000 tons)	Value of landings (million Euros)	Direct subsidies (million Euros)	Total Income (million Euros)	Average wage per FTE (Euros)	GVA (million Euros)	Operating cash flow (million Euros)	Profit / loss (million Euros)	Capital Value (million Euros)	ROI (%)	Investments (million Euros)
BEL BeamTrawl 24-40	47	245	10	14	55	0,9	57,0	67	15,7	0,0				2,2
DNK PelaTrawl 24-40	51	248	9917	127	54	140,9	55,3	56	25,3	11,6	-3,6	85,8	0,0	2,5
DNK PelaTrawl 40XX	32	216	5501	405	107	0,0	108,9	101	70,4	48,6	1,3	404,7	0,0	21,1
GBR DemTrawlS 1824	223	1103	40	50	107	5,7	120,6	25482	42,5	20,1	11,8	181,4	0,1	9,5
GBR DemTrawlS 2440	109	715	22	59	105	6,0	120,7	37466	37,9	17,1	10,2	155,2	0,1	7,4
GBR PotsTraps 00-10	1926	1184	277	21	63	1,6	70,6	15289	46,7	30,2	8,9	111,6	0,1	0,6
GBR PurseSeine >40	29	125	2	262	152	5,6	159,3	273032	92,0	63,4	30,7	585,9	0,1	6,8
NLD BeamTrawl 1824	164	478	19	17	62	0,0	63,5	36659	30,6	14,3	2,8	81,7	0,1	3,6
NLD BeamTrawl >40	65	468	12	30	125	0,0	125,3	50988	36,8	13,6	-4,7	223,0	0,0	3,8
NLD PelaTrawl 40XX	13	508	3	320	142	0,0	142,3	0	48,7	12,6	-4,7	229,6	0,0	1,0

Even though the highest level of revenues from North Sea landings is obtained by Dutch beam trawlers over 40m, there are two fleet segments showing an higher income: the English purse seiners over 40m and the Dutch pelagic trawlers over 40m. In particular, British purse seiners over 40m with just 29 vessels and 125 FTE (total employment) shows also the highest gross value added (GVA), operating cash flow and level of profits in 2008. Another important fleet segment in terms of GVA and operating cash flow is represented by the pelagic trawlers over 40m from Denmark. This fleet shows also the second highest level of profits with 12 million Euro, even if this is not comparable with the almost 31 million Euro obtained by British large purse seiners.

In contrast, negative profits are registered for Dutch beam and pelagic trawlers over 40m. This is also the case for the Danish pelagic trawlers 24-40m, this fleet segment being, on the other hand, the one beneficiating from the highest amount of subsidies.

Finally, the British demersal trawlers and the British vessels using pots and traps are the most important fleet segments in term of vessels number and employment, and exhibit intermediate values for all economic indicators considered.

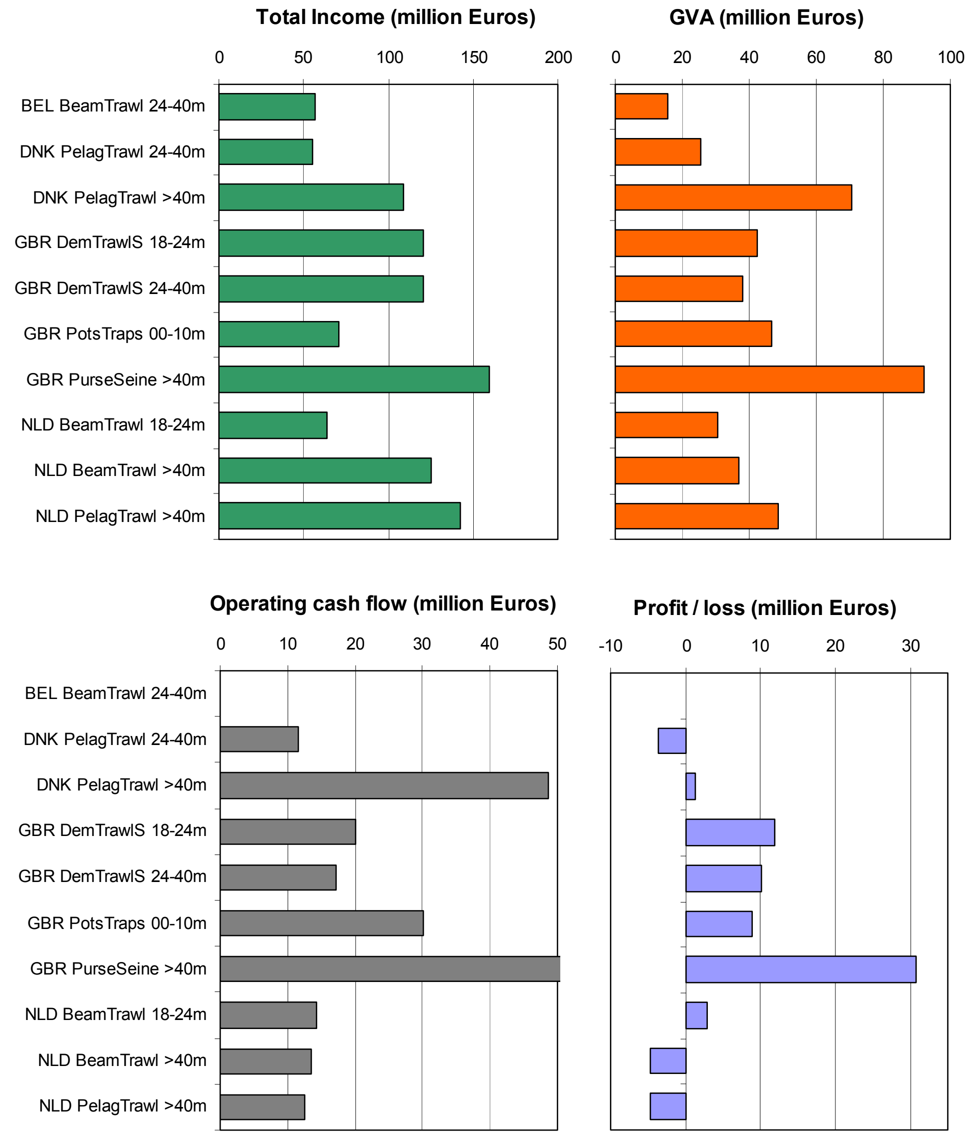


Figure 4.19 – Main economic indicators for the selected fleet segments operating in the North Sea (source AER 2010, data 2008)

- Partial F: contribution to the fishing mortality of assessed stocks

The partial fishing mortality by fleet segment has been estimated for each of the assessed stocks on the basis of the landings of the fleet segment on the total landings of that stock in the area (a detailed description of the methodology is reported in section 2.3 ToR3). The some of partial F by fleet is a measure of their impact on assessed stocks. It can be consider an indicator of the global impact of the fleet on the North Sea ecosystem (Fig. 4.20).

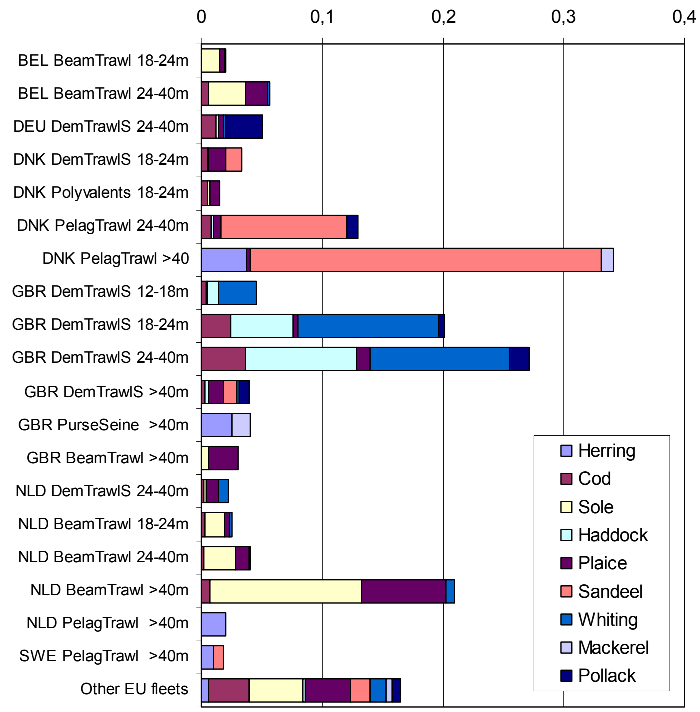


Figure 4.20 - Partial F applied by the selected fleet segments to the stocks assessed by ICES

The analysis of the fishing mortality by fleet developed for the nine North Sea stocks assessed by ICES shows that global impact due to each of the selected EU fleets remains moderate, with total values of induced fishing mortality lower than 0.3. Fleet segments inducing the highest impact on North Sea resources are: the Danish pelagic trawlers (due to their impact on sandeel), the British demersal trawlers between 18-24 and 24-40 m (mainly due to their impact on whiting and haddock) and the Dutch beam trawlers (due to impact on sole and plaice).

The analysis also highlighted the main fleet segments affecting each stock. In particular, 35% of total F on sole and 28% of total F on plaice are due to the Dutch beam trawlers over 40m. As for haddock and whiting, the main fleet exploiting these stocks is represented by the British demersal trawlers between 24 and 40m, which partial F equals to 37% and 25% respectively of total F. An additional 25% of total F on whiting is due to the fishing activity of English demersal trawlers between 18 and 24m. Regarding sandeel, more than an half of total F is due to the Danish pelagic trawlers over 40m.

- Dependency of the fleet segments to the North Sea

All fleet segments, except the largest Dutch pelagic trawlers, are highly dependent on the North Sea. More than 80 % of the total value landed by the fleet is coming from the North Sea for 3 fleets: the British demersal trawlers 18-24m, and the Dutch beam trawlers 18-24m or larger than 40m. Dependency is also high (more than 60 %) for all others demersal or beam trawlers, while small British vessels using pots and traps and large British purse seiners depend for around a half of their landings value from the North Sea.

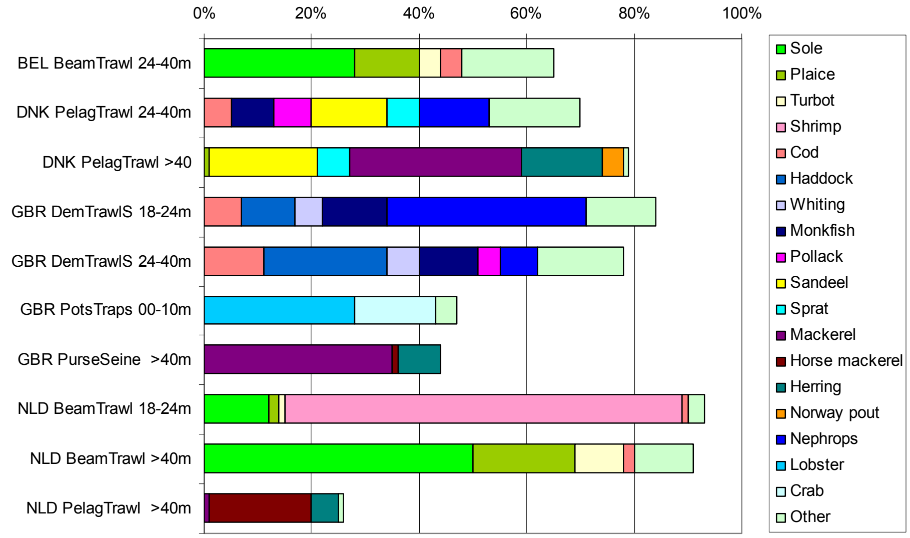


Figure 4.21. Dependency of the selected fleet segments on the North Sea, in term of landings value (source 2010 data call for AER, data for 2008)

- Sustainability index by fleet segment

An index of sustainability by fleet segment has been defined to identify if fleet segments are exploiting resources of the North Sea in a sustainable way or not (see methodology in section 2.3 ToR3).

Among the 10 selected fleet segments, six are exploiting resources which are not sustainable on average, according to the precautionary approach. For three of them, neither the Fpa nor the Bpa limits are met: the small British vessels using pots and traps, the large British purse seiners and the large Dutch pelagic trawlers. For the first one, the bad sustainability index is in fact an artefact, vessels using pots and traps mainly targeting resources which are not assessed by ICES (lobsters and crabs). As for large purse seiners and trawlers, they are mainly targeting mackerel, horse mackerel and herring which were all in bad situation in the reference year (2008).

In contrast, four of the selected fleet segments are exploiting stocks that are, on average, in the secure zone of the precautionary approach. This is the case for all the selected beam trawlers (exploiting mainly sole and plaice whose stocks are in a rather good shape in the North Sea) and for the large Danish pelagic trawlers. Nevertheless, it has to be notice that all these fleets are still outside of the new “green zone” defined by the MSY target.

In short, even if preliminary this analysis seems to indicate that for 100 % of the selected fleet segments the assessed stocks they are exploiting (which sometime may constitute only a limited part of their catches) are globally overexploited, this over exploitation being unsustainable for 60 % of the fleets. Of course it will be of great interest to follow the trajectory of each fleet segment during the coming years, when the new MSY approach will enter in force.

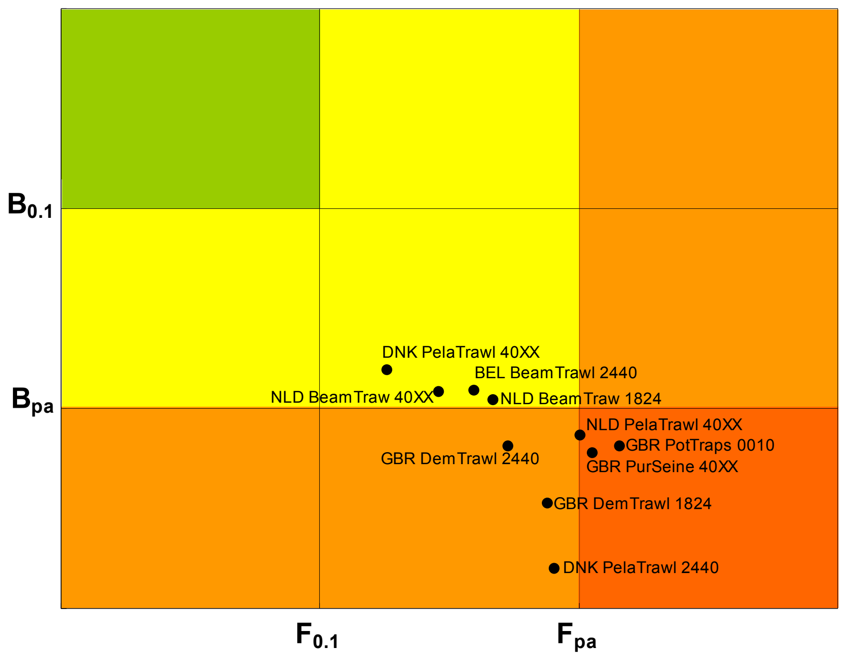


Figure 4.22 – Sustainability index of the selected fleets operating in the North Sea: standardized fishing mortalities F* applied on average on exploited (and assessed) stocks and standardized biomass B* of these stocks, in relation to the limits of the precautionary approach (Fpa and Bpa) and to the new MSY targets (using $F_{0.1}$ and $B_{0.1}$ as proxies).

4.5. Models availability

A comprehensive Ecopath with Ecosim (EwE) model of the North Sea, comprising 68 functional groups and 12 fishing fleets, and incorporating time and spatial dynamics was published by Mackinson and Daskalov (2007). The technical report includes data sources, assumptions and detailed outputs of sensitivity testing. The various chapters concerning particular functional groups are co-authored and have been peer-reviewed by international experts. The model has subsequently been used to investigate the relative roles of fishing and changes in primary production on changes in ecosystems around the world (Mackinson et al., 2008), and to evaluate Maximum Sustainable Yield (MSY) within a multispecies context, on behalf of the North Sea Regional Advisory Council (Mackinson et al., 2009).

Spatial analyses to evaluate the efficacy of planned and existing marine protected areas in the North Sea are underway, preliminary work having been reported in LeQuesne et al. (2008). Recent work has been focussed on four tasks (i) re-specification of the linkage between life stages using multi-stanza representation (ii) updating economic data based on AER 2008 and evaluating the effect of subsidies in the North Sea (Heymans et al. in prep), (ii) updating the proportion of the landings and discards of each species taken by each of 12 fleet defined by the DCF, as reported by STECF 2003-2007, (iii) including environmental drivers in dynamic simulation. In updating the model, a comprehensive time series data set consisting of 240 variables covering 1950-2008 has been compiled and is being used in an empirical analysis of changes in the North Sea. Through ICES WGSAM current work is focused on establishing a 'key-run' (ICES WGSAM 09), further investigation of the relative roles of fishing and climate on North Sea dynamics, and coupling the foodweb to biogeochemical models (through the MEECE project) (Beecham et al. in prep) so that future scenarios of climate change can be more adequately represented.

Numerous bioeconomic models has also been developed focusing on the North Sea area. A lot of them mainly focus on one fish stock/fishery. For instance, a bioeconomic model is specifically developed to conduct a rent assessment study for the North Sea herring fisheries (Bjørndal et al., 2010).

Numerous examples were initiated within the large EFIMAS project (2004-2008, EU FP6 Research Project, www.efimas.org) which aimed at developing tools for evaluating scientific advice and decision making process in fisheries management systems, and in particular extending the started Fishery Library in R (FLR). One of the EFIMAS case studies was dedicated to the North Sea fisheries, building models for evaluating management scenarios on the North Sea roundfish and flatfish fisheries. Several studies of scenario evaluations have then been undertaken using FLR as evaluation frame testing some proposals for fishing effort reduction (Grift et al. 2005), or the new implemented effort regime for the North Sea together with the TACs (Poos et al. 2006, Pastoors et al. 2007) or focusing on the North Sea plaice EU management plan (Machiels et al. 2006 subsequently extended with economic models by STECF 2006 and Oostenbrugge et al. 2008) or North Sea Haddock (Needle, 2008).

If lot of studies within EFIMAS for the North Sea focused on developing the operating models related to alternative stock status and various management procedures within the management strategy evaluation (MSE) framework, some other developments place more focus on designing the fleet-based operating model in a more *stricto sensu* bioeconomic context (see a review in ECONOWS 2008, the TEMAS evaluation frame software in Ulrich et al. 2007 and Andersen et al 2010, the FLR applications with Hamon et al. 2007 or Hoff and Frost 2008) which are for some of them now incorporated to the ICES advice system (ICES WGMIXFISH using Fcube in Ulrich et al. 2009 and in press, further developed in FcubeEcon by Hoff et al. 2010).

The fleet-based models were typically the finest bio-economic models used so far in the North Sea for scenario evaluation. An alternative way would be to focus on individual vessels (Beecham and Engelhard 2007, Bastardie et al. 2010). The advantage of this last approach would be to capture individual vessels characteristics and improve the economic realism of the models because the economic situation is different for the different vessels. Individual-based models are also well suited to capture the variable fishing costs depending on vessel-specific effort allocation in time and space, without requiring a statistical cost function linking the cost for fishing to some levels of stock abundance.

4.6. Summary of the North Sea results - Conclusion

Some of North Sea resources, such as herring and cod have been intensively exploited for centuries. Nevertheless, the fishing pressure has strongly increased since World War II and a much wider range of species (i.e. a larger part of the ecosystem) became exploited since the 1960s. Total landings peaked in the mid 1970s, before decreasing by more than a factor 2 during the last three decades. From 1985, the mean fishing mortality has been constantly decreasing, accelerating the decrease observed in the total catches.

At the same time, the total spawning stock biomass has not changed, indicating a non-recovery of the ecosystem. All the 10 stocks assessed by ICES are overexploited (with fishing mortalities higher than F0.1), 40 % of them being considered in an unsustainable state, from the precautionary point of view. We concluded from the stock synthesis that the decrease of the mean fishing mortality has not be strong enough and/or long enough to allow the recovery of the North Sea ecosystem from a strongly exploited state.

Ecosystem indicators calculated by EU working groups or research program, and gathered by the present SGMOS working group, confirm that in its current situation, the North Sea ecosystem cannot be qualified as being exploited sustainably. While the fishing pressure seems to decrease, several ecosystem indicators are still deteriorating. Only one (the proportion of large fish) indicates an improvement, but it remains bellow the target.

As for the Celtic Sea, the fleet based analysis performed by the working group was still preliminary, because of the lack of data coming from the 2010 data call for AER (French data for instance were not reported). The major aim of this analysis is to show that simple indicators can be estimated to assess both the economical and ecological performances of the various fleets operating in the North Sea ecosystem. Great contrasts exist between fleet segments. Some of them (the Danish pelagic trawlers 24-40m for instance) appear to be largely subsidised, while they seem to be characterised by low economic performances and induce strong impacts on resources, exploiting stocks which are in a bad shape. In contrast, some fleet segments seem to exploit resources in a more sustainable way. Identifying this type of contrast should be a first step to develop a fleet based management.

Regarding ecosystem models, a lot of work has already been done in the North Sea. Both trophodynamic and bio-economic models have been developed. Of course more work is still required before concluding that simulations using such models have to be part of the EAFM advice process. In this perspective, the SGMOS working group recommends that a specific meeting will be organized in order to test the ability of these models to simulate various fishing management scenarios in the EAFM context.

5. HOW TO IMPROVE EAFM IN EUROPEAN SEAS

This chapter of the report is dedicated to more general comments, based on discussion between the experts present during the study group meeting. In the first paragraph some general comments are presented regarding the method tested during the working group, in reference to ToRs 1 to 5. In the following paragraphs, terms of reference 6 to 9 are more specifically addressed.

5.1. Comment on the methods used by the study group (ToRs 1 to 5)

Through terms of reference 1 to 5, and based on the two case studies, one of the main objective of the working group was to test a general approach, and to analyse the feasibility of building useful ecosystem advice. General comments can be made regarding what was learned from this test.

- **ToR1 Catch reconstruction.** Reconstructing long time-series of catch by species (or group) appears to be a necessary step within the ecosystem approach to fisheries. It obviously provides a long term perspective on the exploitation history which has to be kept in mind when looking at the ecosystem health in the recent period.

Realistic time series of landings can be easily built in each European ecosystem since 1950, on the base of ICES Statlant data (and using for 1950-72 simple hypotheses for the repartition of landings by subdivision). These time series constitute a first important approach for an overview of catch trends although not precise. Nevertheless, the North Sea case study clearly illustrates that ICES Statlant statistics underestimate the real catch due to misreporting and discards. The use of time series estimated during a research program, such as the ones shown for the North Sea, provides certainly a more accurate and longer perception of the exploitation history.

The working group was not able to provide during the meeting any estimate of the fishing effort trends over a long period. Such time series is likely to exist in the scientific literature or could be rebuilt within specific research programs. This means that more work is required before establishing such time series for all ecosystems. This effort should be considered as an important need for the EAFM.

- **ToR2 Stocks synthesis.** The “stocks synthesis” appears to be a key part of the EAFM. Using results based on single species assessments to build an ecosystem approach may not be perceived as an intuitive method. However, such synthesis at the ecosystem level provides an important overview on the best estimates we currently have regarding the status of all the assessed stocks exploited within the ecosystem.

We choose to build this synthesis using F_{pa} and $F_{0.1}$ (and B_{pa} and $B_{0.1}$) so that the status of each stock is defined with reference to both the “old” precautionary reference values and to the new MSY reference values. The new MSY-based objectives should be reached (for F) in 2015 and it will be especially interesting to monitor the stock’s trajectories (for each individual assessed stock or as a whole) in the coming years.

Accordingly to STECF advice, $F_{0.1}$ was used as a proxy of F_{MSY}, as no direct estimates of F_{MSY} are currently available for most stocks. This approach could be improved in the near future, if appropriate estimates of F_{MSY} become available. Because in the current exercise the purpose of the stock synthesis is to draw a general picture of the stocks’ status at the scale of the ecosystem (and not for instance to estimate TAC per stock), coarse estimates (or proxies) of F_{MSY} are sufficient to be informative.

The stock synthesis is also based on mean indicators and trajectories calculated for all assessed stocks. Simple averages were used by the working group as a first step, but other methods should be tested in the future (e.g. geometric or weighted means). Moreover, the compromise between longer time series of few assessed stocks versus shorter time series representing more species has to be carefully made and deserves a deeper consideration. Furthermore, only stocks assessed by ICES were presently considered, while other stocks locally assessed by national bodies should be included in future analysis.

To be powerful in an EAFM perspective, such a stock synthesis implies that a large part of the exploited stocks, if not all of them, would be assessed. From this point of view, we observed not only differences between ecosystems but also changes over time. In the last years the proportion of landings coming from stocks that are assessed by ICES has globally decreased, especially in the Celtic Sea (from 70 to 30 % of the total landings). This is due to a decrease in the number of stocks that ICES working groups are able to assess (mainly caused by the lack of data delivery from Member States) and to an increase of landings of stocks which are not assessed (or stocks assessed by national bodies).

In contrast, the SGMOS working group considers that assessing all resources exploited as target should be considered as a requirement of the EAFM. It should be admitted as a general ethical rule that exploiting natural resources implies a scientific survey (no assessment, no fishing). Thus, the SGMOS working group suggests STECF should recommend that an increasing proportion of the stocks targeted by European fisheries should be assessed by ICES, European programs or national bodies. Such assessments should not necessarily be provided on an annual basis and using the same full set of age-based methods. They could clearly consider various approaches, based on surveys and/or models according to species and fishery characteristics. As for non targeted species exhaustiveness is probably not realistic, a strategy has to be defined in order to assess a number of stocks sufficient to provide a representative overall assessment of the exploited part of the ecosystem. Thus, defining this strategy in all ecosystems, building a database on assessments and gathering the necessary data for the scientific survey of all exploited stocks has to be considered a high medium-term priority.

- **ToR4 Ecosystem indicators**. Due to time constraints and lack of data (i.e. international VMS data), the SGMOS working group was not in position to recalculate the ten ecosystem indicators included in the reference list as well as values for the mean trophic level (as suggested by STECF) for both ecosystems. Its mandate, as define by the ToRs, was more to gather results obtained from other working groups or research programs.

From this point of view, the SGMOS working group notes that such estimates are rather scarce, or usually provided at a geographic level which does not match with the studied ecosystems. For instance, indicator number 10 on fuel efficiency was calculated by JRC per fleet segment and country without taking into account the fishing area and thus without reference to any ecosystem.

Some ecosystem indicators can be calculated for all European ecosystems using data collected as part of the Data Collection Framework (DCF), or using databases which are now available on the Web. That is especially the case for indicators based on scientific surveys or VMS data. Nevertheless reference ecosystems have to be defined prior indicators can be estimated in a homogeneous way and used operationally. This question is detailed below in relation to ToR7 (see §5.3).

Other indicators cannot be estimated for the moment at the ecosystem level using available data. This is especially the case for indicator number 10 on fuel efficiency, which is based on data from the DCF referring to large areas (Baltic, Atlantic waters and Mediterranean Sea) that do not necessarily match specific ecosystems. This limitation is also encountered for all economic data and will be discussed below in relation to ToR5.

The North Sea case study highlighted another important aspect. A large research effort has been done in this ecosystem regarding methods used to estimate or interpret indicators, especially under the auspice of the ICES WGECO and within EU-funded research program (e.g. IMAGE, MEFEPO). It can be concluded from this work that, even if agreed by ICES and STECF, the reference list of ecosystem indicators can not be considered as defining an operational tool. Recent and new results regarding methods required in calculating indicators 1 to 7 of the reference list are presented in Chapter 4 and Appendix 3. Results from Chapter 3 seem to confirm that the mean trophic level could also be of interest as an ecosystem indicator. Nevertheless, more work is still required before adopting a single consistent protocol on the calculation of indicators, as well as appropriate reference values for each of them.

The SGMOS working group considers that this work on ecosystem indicators should be the task of a specific (and probably permanent) working group, whose terms of reference would be to provide the best possible estimates of ecosystem indicators on a yearly basis, for all European ecosystems (as defined in the reference list; see §5.3). Discussion with ICES should determine which working group (e.g. ICES WGECO) could be the appropriate group in charge of such a task.

- **ToR 3 and 5 Fleet-based synthesis.** Fleet-based synthesis, using indicators of both the ecological impact and the economic performances of fleets operating in the ecosystem, also appears to be a key step of EAFM. Several aspects were discussed by the working group.

. Methodological considerations on ecological indicators per fleet segment

We present here a first attempt (and, as far as we know, a completely new approach) using stock assessment results to derive indicators of the impact of each fleet segment on the exploited resources of an ecosystem. For that purpose we used the best knowledge issued from ICES assessments to characterize the fleet impact on the fishable fraction of the ecosystem. In that sense, this approach has to be considered part of the EAFM.

Due to the poor quality of the data available from the 2010 AER data call (with for instance no data at the right desaggregation level for some member states), the results we obtained should be considered very preliminary and thus interpreted with great care. Nevertheless, from a methodological point of view the test was successful. Partial mortalities and sustainability indices allow to highlight significant contrasts between the various fleet segments operating in the ecosystem, in term of their global (and direct) impact on the fishable fraction of the ecosystem. Assessment diagrams based on standardized F* and B* show whether each fleet segment, on average, sustainably exploits the stocks compared to the $F_{0.1}$ and Fpa (or $B_{0.1}$ and Bpa) targets. Naturally, this approach is more powerful when the fraction of the total fleet landings included in the analysis comes close to 100 %. Note this endorses again the fact that all exploited resources should be taken into account in the assessment process (see recommendation above, in § on ToR2).

A more important limitation of the approach is that only direct impacts on exploited species are considered. Neither impacts on habitat (e.g. due to trawling and dredging), nor indirect impact to other ecosystem compartments through the food web are addressed. This, however, is something that could be developed and would nicely complement much of the information presented for ToR 4. The impacts on habitat require specific studies while the impacts on other food-web components are considered in usual ecosystem models (see §5.2). These indirect impacts have to be included in the future within a more complete framework for the assessment of ecological impact of each fleet segment. Furthermore, other more integrated approaches, such as LCA (Life cycle analyses), should also be investigated in order to analyse the environmental impact of various fishing practices.

SG-MOS highlights that the work done during the meeting has to be strictly considered as a first step. This step is clearly incomplete but is also very important in the frame of EAFM as it links the stocks with the fleets (i.e. also State and Pressure in the PSR paradigm). Consequently SG-MOS concludes that this work should contribute to allow moving from a stock-based management to an integrated fleet-based management of fisheries. In such an approach, stock by stock assessments will remain essential (and stock by stock regulation will certainly remain required), but additional fleet-based tools and regulation will have to be developed.

. *Methodological considerations on economic indicators*

As underlined in the data consideration section (§2.3), description of the economic performances by fleet are available in the framework of the DCF by country but no methodology of disaggregation of these economic performances between different ecosystems is available. Therefore, the methodological question of using economic performances by fleet and country as a proxy to describe the performance of fleets operating in a specific ecosystem was addressed in the working group.

The proportion of the total value of landings of the fleet caught in the studied ecosystem gives an indicator of the dependency of the fleet to the ecosystem and a proxy of the time spent in the ecosystem. When this indicator is high, i.e. when the fleet spent most of its time in the ecosystem studied, it can be considered as a satisfactory proxy to describe the economic performances of the fleet in this ecosystem using economic indicators available in DCF even if they are not disaggregated by region or ecosystem. When dependency of the fleet to the ecosystem is low, fixed costs by fleet can be used to describe the economic performance of the fleet studied as they are not related to the activity.

Concerning variable costs the problem is more accurate. No specific methodology is available to disaggregate variable costs at specific spatial levels. Variable costs could be allocated according to the effort in a considered area. Another method would consist in describing variable costs as a percentage of the gross revenue by area. However, this assumption omits heterogeneity in the spatial productivity.

Further analyses have thus to be conducted in order to define a method for disaggregating economic performance at the ecosystem level. The SGMOS working group considers this should be done by or in close cooperation with SGECA working groups (see below for more general recommendations dealing with economical analyses).

SG-MOS finally concludes that data availability at regional level is the key question. The SGMOS working group advices that implementing EAFM in European seas should lead to an in-depth revision of the DCF. Tradeoffs between ecological impact and economic performances should be provided on an ecosystem basis. Therefore economic analysis at the ecosystem level are clearly required while economic data are currently collected within the DCF only with reference to the three very large marine areas: the Baltic Sea, the Atlantic waters and the Mediterranean Sea. SG-MOS recommends that revised DCF should consider the ecosystem spatial reference for collecting the data using an agreed list of clearly defined ecosystems (see §5.3).

. Building tradeoffs between ecology and economy - Towards a fleet-based management

In the case of the Celtic Sea, we presented a very preliminary attempt to draw tradeoffs between ecological impact and economic performances of the selected fleet segments, crossing the sustainability index with the economic dependency to the ecosystem. Other tradeoffs should obviously be tested and analysed, crossing for instance cash flow or profits or subsidies (…) with fishing induced mortality or sustainability indices. This could especially help to determine which indicators are the most helpful or suitable to draw suitable and helpful tradeoffs in the frame of EAFM.

The SGMOS working group considers that improving the method, defining a general homogeneous and agreed framework for fleet-based environmental assessment, and applying this framework progressively to all the European marine ecosystems, should be the task of a specific and probably permanent working group, gathering both ecologists and economists. The group suggests that SGECA working groups could be the right place to develop this kind of approach. Discussion within STECF should evaluate this possibility.

The environmental assessments will likely highlight differences in fleet ecological impact and economical performance. Some fleet segments will likely exhibit simultaneously strong ecological impacts and poor economic performances, while others will probably appear more virtuous from both points of view. We already saw that such contrasts can be identified in our analyses. For some other fleet segments the analysis will be more complex and a global assessment will have to integrate a compromise between ecological and economic indicators. Note that such a compromise generally occurs in the environmental assessment of all industrial activities. Fishing practices are no exceptions. SG-MOS considers that marine ecosystems, such as the ones taken into account by the working group, appear to be the correct level to build and analyse this type of compromises.

Following the logical analysis of the approach, SG-MOS raises the question of what to do with such assessments. The ecosystem assessments could clearly be part of a framework used to determine which fleet segments would have to be reduced and which ones could be developed. Environmental assessments should also be used to guide management plans for fishing effort or to introduce positive or negative economic incentives in order to encourage fleets to improve their fishing practices. The payments for ecological services are quite common in agriculture to preserve certain ecosystems and reduce pressure on them. However, this is not easily transferable to fisheries management. At the moment payments for more environmental friendly fishing gear are part of the European Fisheries Fund (EFF) but overall the use of this gear types are often a risk for fishing firms competing with companies using probably more efficient methods with more negative external effects on the ecosystem.

SG-MOS concludes that the challenge is not to replace the stock by stocks regulation which noticeably remains a necessity, but to develop an additional fleet-based management. The environmental assessment must be part of that additional management of fleets (another important part being the ecosystem and fleet-based modelling; see below).

5.2. Models (ToR 6)

5.2.1. Availability of models

The development and application of multi-species and ecosystem models relevant to the ICES eco-regions and more widely has been published in comprehensive reviews given in ICES WGSAM 2007 and Plaganyi 2007. ICES WGSAM reports from 2007 onwards provide regular updates on modelling progress and future developments, with forums such as the Advanced in Marine Ecosystem Modelling Research (AMEMR) conference (next in 2011) providing updates on state of the art.

Ecosystem mass-balanced models such as EwE (Ecopath with Ecosim, Christensen and Pauly 1992; Walters *et al.* 1997) have been used worldwide, especially to analyse ecosystem impact of fishing or to simulate various changes in the fishing pressure. The EcoTroph model (Gascuel and Pauly 2009, Gascuel et al 2009) has been recently added as a EwE plug-in and is especially devoted to draw global diagnosis of the fishing impact on the whole food web.

It has to be noted that trophodynamic models usually include a large number of elements in the food web but with a poor spatial and temporal resolution (one box by regional sea, annual time step). On the opposite, biogeochemical models contain generally a limited number of food web components but they are coupled with hydrodynamic models and have a high spatial and temporal resolution. In the future, fishery-based models will likely need to be more spatially and temporally derived for reflecting the variability of habitats and ecological niches and better interpreting the stock's variability. Thus, there is an increasing interest in the scientific community for spatially-explicit food web modelling from hydrodynamics/plankton to fish. None of these model types are mature at present to be used operationally, and the gap between hydrodynamics-plankton-based spatially-derived models and non-spatially-derived fish-based models still exists. However, growing computing capacities (doubling every 1.5 years) will ease the development of complex End to End (E2E) approaches. Fish habitat modelling and mapping has also the potential to facilitate the "spatialisation" of fishery models and the "reality" of E2E food web models.

Experience also shows that trophodynamic models contribute efficiently to assess the global impact of fishing on the food web. They can be used to monitor changes in ecosystem health over years or to compare various ecosystems and draw general diagnoses. Models have also been used with large profit to analyse indirect impacts, trough trophic relationships that exist within an ecosystem, of any changes occurring in the fishing system SGMOS foresees that this type of model could efficiently be used to test the ecological impacts of various management scenarios.

In addition EwE models are likely to provide a set of economical indicators and have already been used in a bio-economic perspective. Nevertheless such food-web models mainly focus on the long-run effect of alternative fishing pressures (using e.g. an overall fishing mortality F per fish species) on productivity and/or the ecosystem health rather than on the potential short-term socioeconomic effect of ecosystem or regulation changes on the heterogeneous fishing sector (e.g. at the fleet-segment level). Bio-economic models intend to assess whether the short-term impact of regulation on fishermen revenue is acceptable, i.e. if they would still meet the costs in a fluctuating environment without considering the nature and importance of these fluctuations. Prellezo et al. (2009) reviewed such existing bio-economic models that are mainly used in Europe.

Among these models, evaluation approaches (MSE, Management Strategy Evaluation in Smith et al., 1999; Punt and Butterworth, 1995) provide a valuable framework to assess the effect and test scientific recommendations of management measures (such as TACs, closures, gear modifications and monitoring schemes) so far mainly on stock trajectories. One example of such a framework is given by the ongoing Fisheries Libraries in R (FLR, an extension of the R programming language; Kell et al., 2007), a generic toolkit which aims at evaluating the effect of combined management rules.

Management Strategy Evaluation is a benchmark tool associating an operating model (i.e. alternative model describing the "real dynamic" of stocks and fleets) and a decision model related to the set of management measures in force or to be tested (e.g. some harvest control rules). The operating model is dynamically coupled with the management procedure within a full-feedback loop. Thus MSE is a very powerful approach integrating the combined and propagated effect of various changes of the ecosystem (resource abundance, environmental forcing, regulation regime, fleet-specific reactions, etc.) in the stock dynamics (and at best on fleets) and in projecting the relative effect of different scenarios. Uncertainties in these projections can further be handled when stochastic simulations are carried out accounting for errors occurring at various steps in the whole process, e.g. observation model error, assessment model error, poor enforcement of the regulations.

The level of complexity of current MSE applications is questionable. Multi-stock approaches, or multi-species approaches if species interactions are handled, are still scarce in that kind of framework while more elaborated fleet-based models have mainly dealt with single stock evaluation so far (e.g., Bastardie et al., 2010). On this line, current bio-economic models and ecosystem models are showing an increasing mutual interest (e.g., ICES WKIMM, 2010). The former accounts for regimes of fishing regulation and economic evaluation or advice and the latter refines the operating module (e.g. GADGET/FLR coupling in Howell and Bogstad, 2010) and simulates forward the stocks and fleet dynamics in a broader ecosystem context.

5.2.2. Using operational models to produce scientific advices, in the frame of EAFM

The improvement of methods for modelling marine ecosystems and fisheries is currently the aim of many research programs. This field of research is clearly moving fast and many aspects are still under construction. Therefore there is no doubt that working groups and research projects devoted to model improvement will remain required in the coming years and may directly impact the use of models in fisheries management.

At the same time, operational models do already exist and many projects have provided knowledge, simulations or diagnoses to fisheries management. However these research efforts and results are not directly included in the institutional process leading to scientific advice used by decision makers. There is no working group currently in place, under the auspice of ICES or STECF, to used agreed ecosystem and/or bio-economic models, to test various options for fisheries management and to provide on a regular basis scientific advice after the request of political bodies. In other words, useful tools do exist …but they are not really used or poorly used for the management of European fisheries.

Therefore, the question is: how operational models should be implemented in order to provide scientific advice that can be effectively used in the frame of EAFM? The SGMOS working group considers this has to be done similarly than in the assessment working groups of ICES which are now currently using single species models (more or less homogeneously) in order to provide diagnoses and scientific basis for fish stocks management. The development of an equivalent although different system for AEFM could be undertaken in the two following steps:

1. First, a reference model or more plausibly a set of a limited number of reference models (for instance, one ecosystem model such as EwE and one bio-economic model such as Fcube or using a MSE approach) should be developed or adapted based on the best available knowledge for each one of the 14 European marine ecosystems (as defined in the reference list of ecosystems; see §5.3). The SGMOS working group suggests this could be done trough a specific call for projects managed and sponsored by DG MARE. The terms of reference for such a call should be to implement new models or to adapt existing models whose aim will be, on one hand, to assess the ecological status of ecosystems and the ecological effects of changes occurring in the related fisheries and, on the other hand, to simulate biological, economical and social consequences of various management options. A scientific committee could be set up (or identified if already existing) to coordinate the approaches developed in the various ecosystems and to validate models as reference to be used within the scientific advice framework. Models agreed as reference will clearly have to improve over years according to progress occurring in modelling approaches and in the quantity or quality of the available data.

2. A specific and probably permanent working group should be set up to run the reference models every year (or on a regular basis) updating the diagnosis on ecosystem health in addition to approaches based on stocks-synthesis and ecosystem indicators. The simulation of various options for fisheries management should be performed according to the fleet-based analysis. SG-MOS considers this working group could also be in charge to investigate compromises between simultaneous and often incompatible biological objectives (such as the objective to reach the F_{MSY} simultaneously for every stock). Models should be used especially to identify, simulate and analyse best possible compromises between ecological, economic and social objectives. In practice, the SGMOS working group suggests such a group should be set up rapidly (possibly under the auspice of SGMOS itself), starting with a very limited number of ecosystems (those where reference models can be identified; maybe only one for the first year) and implying both ecologists and economists. On the medium term, as far as models may be developed, more ecosystems will have to be considered and several working groups will become necessary. SG-MOS suggests to split the group, for instance according to RACs.

SG-MOS highlights that the development and the use of models for ecosystem based management will require a significant raise of collected data. On one hand, economic data must refer specifically to a given ecosystems which implies an in-depth modification of the DCF (see above). On the other hand, the improvement of ecosystem models clearly requires new and more data, especially on diets or trophic relationships and on the ecology of the poorly studied components of the ecosystem. SG-MOS notes that the required ecological observation of European seas has a significant cost but specific sampling programs have to be developed.

5.3. Defining the reference list of ecosystems (ToR 7)

The SGMOS working group strongly advices that defining a reference list of European marine ecosystems is the top priority for implementing EAFM. This is the first and key step. The definition of ecosystems that have to be considered in the frame of EAFM is clearly required before building diagnosis on ecosystem health, before analysing fleet economic performances as we did presently in Chapters 3 and 4 and before developing models and setting up working groups in charge to produce scientific advices.

The SGMOS working considers that the Celtic Sea and the North Sea ecosystems used in the case studies represent a good compromise in term of size. These ecosystems are compatible with stocks-based and fleet-based analyses and with modelling approaches as well. Smaller ecosystems can also be considered in more detailed research programs and for local management but a larger scale seems to be more appropriate for providing scientific advice to European political bodies. Larger areas than the Celtic and North Seas would be characterized by a high heterogeneity in terms of both ecological processes and fleet dynamics.

These ecosystems must be defined accordingly to existing limits. Three divisions might be considered:

. Limits of FAO and ICES divisions and subdivisions cannot be ignored. They are the basis for all the catch and effort statistics system and are used to define stocks limits or to specify a lot of fisheries regulations. They can be considered a basis for the Common Fishery Policy.

. Marine eco-regions have been defined in the context of the Marine Strategy Framework Directive (MSFD) (Fig. 5.1). These MSFD marine eco-regions will become a key division in the coming years, as reference areas for assessing the “good ecological status” of marine ecosystems (to be reached by 2020). Nevertheless, these limits cannot be directly used in the frame of EAFM because the good status will be assessed on a national basis and thus limits of MSFD marine eco-regions were defined according to national EEZ. As a consequence, MSFD marine eco-regions do not match with ICES subdivisions limits and fisheries regulation (and more generally with CFP). As an example, a large part of the North Sea is part of the Norwegian EEZ and thus is not included in the MSFD region of the North Sea.

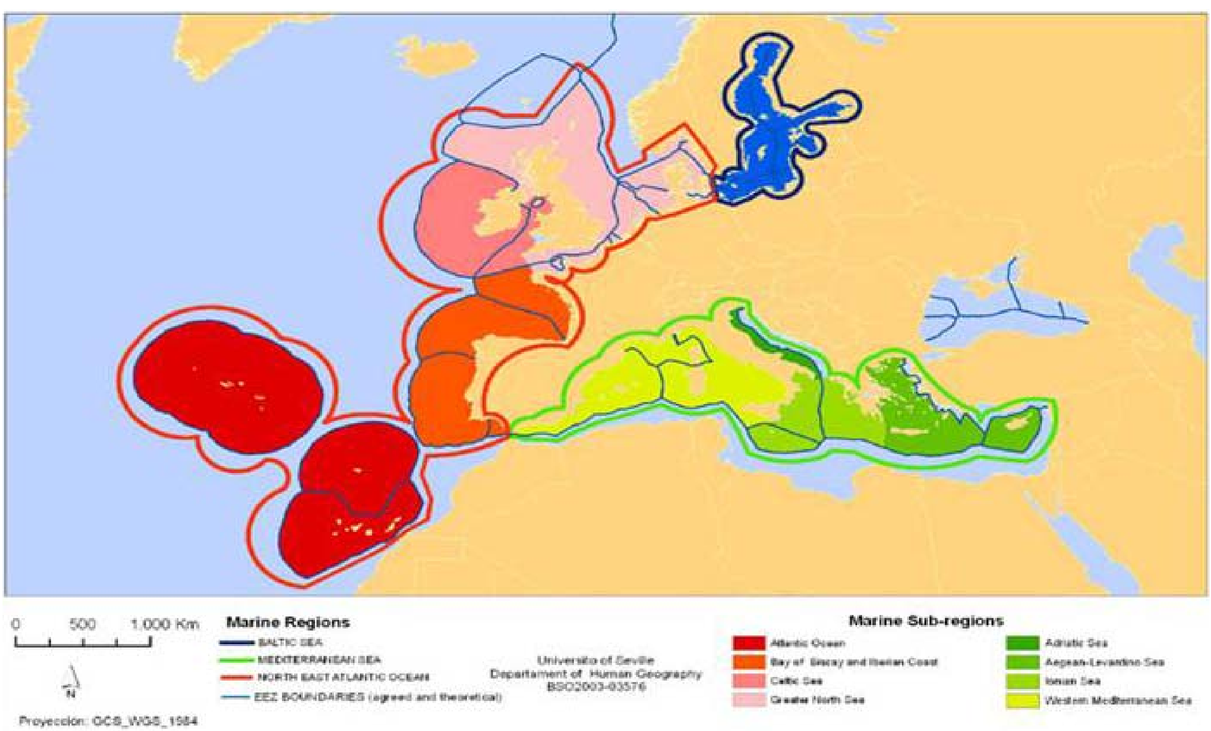


Figure 5.1. Marine eco-regions defined by the Marine Strategy Framework Directive (MSFD)

. The Regional Advisory Councils (RACs) were set up by the European Commission to improve fisheries management on a regional basis (Fig. 5.2). The related limits are clearly consistent with the limits of ICES or FAO divisions. The SGMOS working group considers that the RACs subdivision must be the basis used to define the reference marine ecosystems. However some RACs refer to a very large and heterogeneous region that must be divided into several ecosystems.

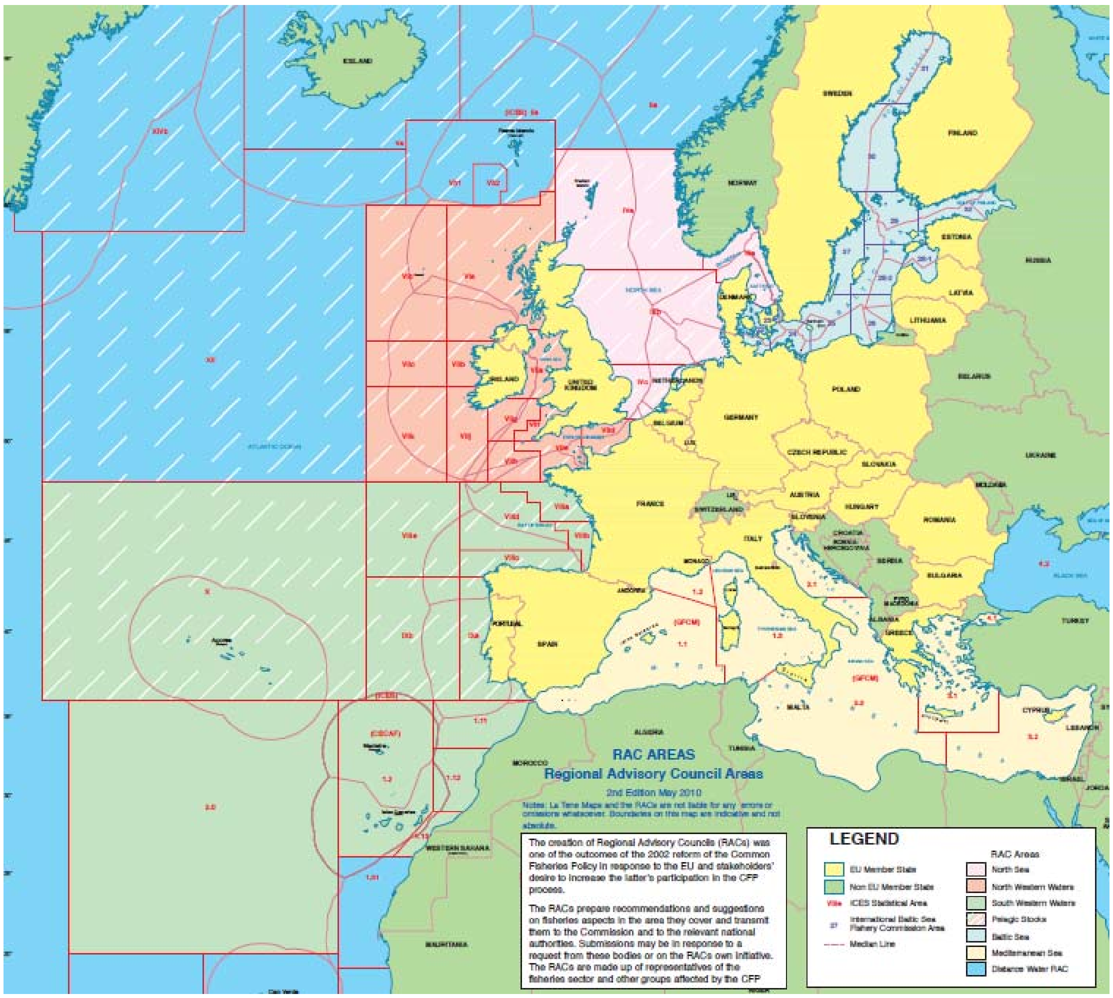


Figure 5.2. ICES and FAO zoning and Marine areas related to European RACs (Regional advisatory committees)

The SGMOS working group therefore suggests that the list of 14 ecosystems presented in Table 5.1 should be considered. This list is based on current knowledge and defines ecosystems according to ecological limits which are usually considered in most scientific research programs or in the scientific literature. These ecosystems are also defined according to ICES/FAO limits and match to the RACs. They are close in their definition to the MSFD marine eco-regions.

SG-MOS emphasizes that such a list has to be officially agreed by stakeholders and political bodies. The SGMOS study group suggests it could be submitted to the advice of STECF and possibly to an experts' consultation before being submitted for consultation with RACs and formally adopted by the Commission.

Table 5.1. Reference list of European marine ecosystems suggested by the SGMOS working group on EAFM

	Ecosystem	FAO subdivisions	Depending on the RAC:	MSFD Marine region close
1	Baltic sea	ICES IIIb, 22-32	Baltic sea	Baltic sea
2	North sea	ICES IVa-c, IIIa, VIId	North sea (except VIId)	North sea
3	West Scotland/Ireland	ICES VIa-b, VIIb-c	North western waters	North sea / Celtic sea
4	Irish sea	ICES VIIa	North western waters	Celtic sea
5	Celtic sea	ICES VIIe-k	North western waters	Celtic sea
6	Bay of Biscay	ICES VIIIabd	South western waters	Bay of Biscay and Iberian coast
7	Iberian coast	ICES VIIIc, IXa	South western waters	Bay of Biscay and Iberian coast
8	Acores	ICES X	South western waters	Atlantic ocean
9	Canarias, Madeira	CECAF 1.2	South western waters	Atlantic ocean
10	Western Mediterranean Sea	GFCM 1.1, 1.2 & 1.3 (GSA 1-12)	Mediterranean Sea	Western Mediterranean Sea
11	Adriatic Sea	GFCM 2.1 (GSA 17-18)	Mediterranean Sea	Adriatic Sea
12	Central Mediterranean Sea	GFCM 2.2 (GSA 13-16, 19-21)	Mediterranean Sea	Ionian sea
13	Eastern Mediterranean Sea	GFCM 3.1, 3.2 & 4.1 (GSA 22-28)	Mediterranean Sea	Aegean-Levantin sea
14	Black sea	GFCM 4.2 (GSA 29)	- none -	

5.4. Annual report on EAFM and organizational aspects (ToR 8)

The SGMOS working group was requested to suggest a general format that could be used for the publication by STECF of an annual EAFM report and an organizational structure that would be responsible for addressing future ecosystem analyses.

The working group had limited time during the meeting to discuss in details the format of an annual EAFM report. However the group considers that such a report would be very valuable. As a first step, it could be based on the format used in the present report that includes a general chapter for methods, a chapter for each ecosystem and a chapter for synthesis and general comments. Consequently, the analysis presented for each ecosystem should ideally include the following aspects: trends in catch and fishing efforts, stock-based synthesis and analysis of ecosystem indicators, fleet-based diagnosis on ecological and economic performances per fleet segment, results of ecosystem and bio-economic models for assessing the effect of management options.

A single SGMOS working group could clearly not be in charge of managing all the analysis required for EAFM. According to previous comments, SG-MOS suggests to start discussions with the other STECF groups and with ICES (and GFCM?) in order not only to share the work, but to mobilize a large panel of experts and to promote an advise-oriented ecosystem approach in many existing STECF and ICES committees. As a first set of proposals, SG-MOS suggests to:

. Draw the long-term picture of trends in catch and fishing effort in all European reference ecosystems. This is likely to require a specific project developed in close relation with the ICES-SGHIST;

- Routinely estimate values of ecosystem indicators (and working on methods). It would be the task of a specific working group, possibly the ICES WGECO (at least for Atlantic and Baltic waters);
- Assess the stocks. This is part of the EAFM and should be extended to as many as possible exploited resources. This will clearly continue to be an important mandate for several ICES assessment WGs. In addition, a specific analysis is required in each ecosystem to determine which part of the exploited stocks is currently assessed and how this could be improved (defining for instance strategies in order to provide a representative overall assessment of whole the exploited part of the ecosystem);
- Perform fleet-based analyses including, for the main fleet segments, the environmental assessments and evaluation of their economic performances. This should be the task of a specific group, possibly under the auspice of SG-ECA;
- A first SG-MOS working group (possibly split per RACs in the future, as mentioned above) could be in charge of updating and running each year the reference ecosystem and bio-economic models to assess changes in the ecosystems and to test various management options; this working group should also take into account specific results from other groups (e.g. ICES WGMIXFISH, …);
- Finally, a second SG-MOS yearly meeting could be in charge of aggregating results, building synthesis and formalize scientific advice under the authority of STECF. The annual EAFM report would be the final product of this group based on an integrative approach of results obtained in several bodies.

It has to be added that JRC should be strongly involved in the process, especially in the management of data call and data base required and participate actively in the annual EAFM reporting.

5.5. General recommendations - Conclusion

The SG-MOS working group considers that setting up a new organisation of working groups devoted to the scientific advice in the field of fisheries ecology and economy, on an ecosystem basis, is a requirement to enforce implementation of the EAFM, and eventually a requirement for the sustainable development of European fisheries.

The feasibility analysis conducted during this working group using the North Sea and the Celtic Sea as case studies confirms that such ecosystems represent the appropriate level:

- to draw syntheses on stock status and analyze trends in ecosystem indicators,
- to study ecological impacts and economic performances of fleet segments,
- to analyze tradeoffs between economy and ecology in order to develop a fleet-based management of fisheries,
- to develop models devoted to scientific advices in both ecological and economical frames.

Ecosystems also appear to be the right entities to improve the dialogue and involve stakeholders (including of course fishermen representatives and especially with regards to RACs), and to build integrated management plans.

Therefore the first step to implement EAFM in European Seas is to officially define the reference list of European marine ecosystems in the same way as stock identities were defined and agreed by the scientific community and the political bodies after World War II. Secondly, two major improvements should be promoted. On one hand, reference ecosystems should be considered in all data collection programs related to fisheries, resources, habitats, etc. It clearly applies to the DCF that should be revised. On the other hand, reference ecosystems should be considered as the functional units used in many working groups from ICES and STECF. It could imply changes in the organisation or in the terms of reference of several working groups. More generally, SG-MOS recommends that such reference ecosystems should be considered in most research programs. The use of a single geographical level in various groups, projects, programs or committees would allow a more efficient aggregation and/or synthesis of results, experiences and knowledge.

SG-MOS recommends that inputs of both ecologists and economists are required. This report clearly demonstrates that ecosystem-based and fisheries-based management approaches are complementary. It also shows that these approaches have to be developed not in order to replace more classical single-species approaches (which are part of EAFM) but as additional tools required in order to enforce the ecological, economical and social pillars of the sustainable development of fisheries.

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APPENDIX 2 - 30TH PLENARY MEETING REPORT OF THE SCIENTIFIC, TECHNICAL AND ECONOMIC COMMITTEE FOR FISHERIES (PLEN-09-01)

Background

Scientific advice on fish stocks and on rules to be taken into account to establish possible fishing opportunities are currently delivered on the basis of last available biological information. Such a process with a stock by stock focus does not allow for the development of management proposals based both on the ecosystem nor for a fisheries metier approach taking social and economical information into consideration.

Even in the cases where economic advices have been delivered it has been generally established in a step-wise process with the economic analysis being added after the biologists having worked the first step. This is surely not the best way to integrate information and analysis by all scientific fields dedicated to fisheries management.

A more integrated ecosystem and fisheries approach is particularly relevant in such contexts where multi-species and multi-métier fisheries are predominant. More generally, it would be also relevant to ease comparison to be made by policymakers and stakeholders when they have to discuss different options and to manage the impact of fishing activities on exploited stocks and ecosystems.

Terms of References

STECF is consequently request to discuss the following points and to discuss and to suggest reliable methodologies and possible improvements to be used and implemented when scientific advice on stocks will be reviewed with the aim to deliver more integrated information to the DG Mare.

1 – Possible integration methods of biological and economic assessments delivered on a stock by stock approach when such stocks belong to species with similar characteristics.

2 – Use of biological and economic indicators characterizing ecosystem status and their exploitation level and sustainability, discussion on the list of indicators agreed by the STECF plenary (already included into the new Data Collection Framework) and related comments to possibly suggest adding trophic and/or socio-economic indicators.

3 – Discuss available and reliable modelling approaches applied to describe ecosystems, particularly EcoPath, Ewe and EcoTroph and bio-economic models.

This discussion should also allow identifying

- ✓ the geographical accuracy to be taken into account when delivering such integrated advice:
  - ecosystems already identified in European waters,
  - fisheries considered as a bio-geographical context characterized by sotck or group of stocks where fishing vessels catch them either as targeted species of associated species by using differents type of gears and by developing different fishing strategies;
  - an areareas coverd by RACs,
  - etc…
- ✓ Modelling approach which would be yet used efficiently in some eco-regions, ecosystems, fisheries and/or on some similar stocks (to be possibly listed).
- ✓ Data which would be needed to run such modelling approaches by segregating those
  - which are available
  - are not available at this stage but which are already included in the new Data Collection Framework
  - which would need complementary sampling protocols
- ✓ Methodological and IT developments which are still needed.

STECF comments

According to the Commission request, STECF firstly made general comments and suggestions on the implementation of EAFM and bio-economic modelling. Secondly, STECF discussed a non-exhaustive list of currently available tools that seem to be useful, and that could be more widely used or tested in Europe, in order to progress in that direction..

<u>1. How to improve the implementation of EAFM and bio-economic modelling</u>

STECF notices that the DG-Mare interpretation of the Ecosystem Approach to Fisheries Management (EAFM) is as follows: "the approach that strives to balance diverse social objectives, by taking into account knowledge and uncertainty about biotic, abiotic, and human components of ecosystems and their interactions and applying an integrated approach to fisheries within ecologically meaningful boundaries" (EC, 2008 SEC(2008) 449). STECF notes that, at present, scientific advice supporting the implementation of the CFP focuses on the impacts of fishing itself. However, as methodologies and data required for more integrated analyses become available, more comprehensive implementation of the ecosystem approach will increasingly take into account all human activities in the marine ecosystem.

STECF recognises that implementing the Ecosystem Approach to Fisheries Management (EAFM) including the development of associated ecological and bio-economic models constitutes an important challenge and an urgent need in Europe. Scientific advice on fish stocks status and fisheries management are mostly delivered on the basis of stock by stock biological assessment; while more integrated approaches should also be taken into account, including the integration of the assessment of fishing at the ecosystem level as well as social and economic aspects. Especially in a multi-species and/or multi-métier fisheries, integrated ecosystem based approach is particularly relevant in order to assess the impact of fishing activities on both targeted stocks and the wider ecosystem, as well as assessing the impact of proposed management measures on the fisheries and metiers concerned.

From an economic point of view, the management of the ecosystem should ideally be based on a valuation of all ecosystem goods and services, including the intrinsic value of, for example, corals, seabirds and marine biodiversity as well as amenity values associated with the marine environment. Although a large literature exists on methods for the valuation of unpriced goods and services (such as contingent valuation), these methods are not unproblematic and may not be suitable for management purposes. From a practical perspective, EAFM will inevitably involve compromises between the economic gains from use of the marine environment (for example, fishing) and the costs associated with unwanted impacts such as habitat damage, loss of biodiversity, cetacean mortality, etc. In theory, if all costs and benefits can be measured, the social optimum can be determined, but in practice it will rarely be possible to measure *all* costs and some "rule of thumb" approach will need to be adopted, such as choosing between scenarios with different ecosystem impacts. In this context, science will need to provide assessments of the ecosystem impacts of different management scenarios.

One of the main and explicit objectives of the ecosystem based approach to fisheries management, as defined under Council regulation (2371-2002), is to optimise economic activity while seeking to minimize the impact on the relevant ecosystem (i.e. damages on habitats or reduction in stock abundance, etc). Obviously, the objective of minimizing the ecological impact should not be understood as an "absolute minimization" (otherwise, one should close all fisheries!), but relatively to a compromise with the economic or social objectives. Various levels of fishing effort and various fishing patterns (including métiers choice) may lead to the same profitability, but induce different stock abundances or ecosystem impacts. A precautionary approach is likely to require the selection of the fishing regime which minimizes the impact at the ecosystem level.

The scale taken into account is crucial and should be relevant for the management purposes. Currently, biological and economic data are available at different scales. STECF suggests that the principle scale of analysis should be the ecosystem and data should be (dis)aggregated accordingly. However, the scale at which meaningful economic analysis can be carried out might differ in cases where the same fleets operate in different ecosystems. STECF suggests that for each of the ecosystems defined, such fleets be identified and the economic links between ecosystems be taken into account in analyses.

It is the opinion of STECF that a first step for improving EAFM and bio-economic modelling is to define an agreed list of "reference ecosystems" (or "marinographic areas"). This scaling should take into account the limits of the RACs, and probably define sub-areas within RACs.

STECF considers it to be an urgent and prior task to setup the organizational structure for addressing future ecosystem analyses. An initial step should be to convene a working group under the auspices of STECF-SGMOS to define a general analytical framework, data availability and illustrate this on some case studies.

2. Some available tools

EAFM and fisheries bio-economic modelling represent a considerable field of research and STECF was not in a position to provide for a comprehensive answer regarding the available tools for ecosystem analysis. However, practical answers to the three questions raised by the Commission can be given:

1) – Possible integration methods of biological and economic assessments delivered on a stock by stock approach when such stocks belong to species with similar characteristics.

Among works recently published regarding graphical representation of biological assessments, three approaches have notably been identified by STECF as potential useful tools. They all have been used in specific contexts but should probably be tested more widely:

i) Garcia and De Leiva (2005) proposed to calculate and to represent the mean trajectory of a pool of stocks on the usual graph of the precautionary approach, using standardized values of fishing mortalities and SSB (standardized values are equal to 0 for the Flim and Blim and equal to 1 for Fpa and Bpa). The method was applied to a pool of 14 demersal and pelagic stocks from the North-East Atlantic area, showing in that case study a global decline from the safe zone to close to the high risky zone during the 1970s and 1980s, and a stabilisation or a limited recovery during the last studied years. STECF notes that such a method could be applied to any pool of species that have been assessed (and for which precautionary approach limits have been defined) in a given region, without particular difficulties. The method can usually be extended to other targets, especially considering Blim, Bmsy, Flim and Fmsy as the boundaries used in such a graph.

ii) Gros (2008) plotted on the standard graph of the precautionary approach the current status of all assessed stocks which are important for the French fisheries. As Garcia and De Leiva values of Flim, Blim, Fpa, Bpa, were previously standardised. Compared to the previous one, such graph misses the dynamic evolution of the system but allows for presentation of the heterogeneity between stocks status.

iii) Froese et al. (2008) built synthetic diagnosis from a pool of species exhibiting similar or closely related biological characteristics. The diagnosis is based on two common graphs of relative isopleths, one regarding yield per recruit and the other biomass per recruit. Such graphs are based on mean parameters of growth and natural mortality and isopleths are expressed as functions of the exploitation rate M/Z and the size at first catch. In such a graph, the current state of each of the considered stocks can be plotted, as well as any state simulating a change in the exploitation rate or in the size at first catch. Thus, STECF notes that such a method allows for simulation of various exploitation patterns, but uncertainty is introduced in the method using mean common biological parameters for all stocks taken into account.

With respect to the integration of biological and economic information, STECF notes that in order to take management decisions, biological assessments (preferably integrated as described above) should be completed with information on fleets (contribution of each fleet to fishing mortality, economic dependency on stocks, technical information, economic information) and co-occurring species (commercial and non-commercial). The information on the economic performance of the fleet is currently available from the DCR on a fleet segment level. It can be linked to the biological information through the species composition (this information is available on the scale of ICES area).

2) – Use of biological and economic indicators characterizing ecosystem status and their exploitation level and sustainability,

A list of ecosystem indicators has been proposed by the STECF (reference STECF/SGRN-06-01 report “Revision of the Data Collection Regulation to take into account the ecosystem approach’; STECF/PLEN-06-02 Report of the 23rd STECF plenary meeting). During its plenary meeting in November 2007, STECF especially noted "Some indicators could be made operational in the short term, based on existing knowledge and data that were already collected as stipulated in the DCR" (see Tab.5.1). This is reflected in the new DCF and was as well communicated by the Commission to the Council and the EU parliament (COM/2008/0187final. Communication from the Commission to the Council and the European Parliament - The role of the CFP in implementing an ecosystem approach to marine management.). Consequently, the DG MARE has requested ICES to provide an assessment according to the definition of indicators 1 to 9 on a regional basis. Additionally, JRC has been requested to provide similar assessments for indicator 10. Results of these analyses are not available at the moment.

Tab.5.1 – List of ecosystem indicators (from the Commission Staff Working Paper: Report of the Ad Hoc Meeting of independent experts on Indicators and associated data requirements to measure the impacts of fisheries on the marine ecosystem. Brussels, 25-27 June 2007, 32p.)

Code	Indicator	Definition
1	**Conservation status of fish species**	Indicator of biodiversity to be used for synthesizing, assessing and reporting trends in the biodiversity of vulnerable fish species
2	**Proportion of large fish**	Indicator for the proportion of large fish by weight in the assemblage, reflecting the size structure and life history composition of the fish community.
3	**Mean maximum length of fishes**	Indicator for the life history composition of the fish community
4	**Size at maturation of exploited fish species**	Indicator of the potential “genetic effects” on a population
5	**Distribution of fishing activities**	Indicator of the spatial extent of fishing activity. It would be reported in conjunction with the indicator for ‘Aggregation of fishing activity’.
6	**Aggregation of fishing activities**	Indicator of the extent to which fishing activity is aggregated. It would be reported in conjunction with the indicator for ‘Distribution of fishing activity’.
7	**Areas not impacted by mobile bottom gears**	Indicator of the area of seabed that has not been impacted by mobile bottom fishing gears in the last year. It responds to changes in the distribution of bottom fishing activity resulting from catch controls, effort controls or technical measures (including MPA established in support of conservation legislation) and to the development of any other human activities that displace fishing activity (e.g. wind farms).
8	**Discarding rates of commercially exploited species**	Indicator of the rate of discarding of commercially exploited species in relation to landings.
9	**Discarding rates in relation to landed value**	Indicator of the rate of discarding of commercially exploited species in relation to the total value of landings. It is one measure of the relative environmental impact of different fisheries.
10	**Fuel efficiency of fish capture**	Indicator of the relationship between fuel consumption and the value of landed catch. It will provide information on trends in the fuel efficiency of different fisheries.

Additionally to this list, STECF also noted in its 2007 plenary meeting Report (STECF/PLEN-07-03) that:

- usual (and available) indicators of fishing impact on biomass or SSB of the targeted stocks are part of the ecosystem approach to fisheries.

- trophic level indicators should continue to be considered as potentially useful in an ecosystem approach to fisheries and that diet data are fundamental to an improved understanding of species and trophic interactions.

STECF also notes that more general descriptors, related not only to fisheries impacts but to ecosystem health, have been approved under the auspices of the Marine Strategy Framework Directive (based on the Water Framework Directive, and OSPAR, HELCOM, Barcelona, and Black Sea conventions). STECF notes that related indicators and methodologies are still to be agreed.

With respect to economic indicators on the fishing sector, STECF observes that during the working groups on the balance between capacity and the fishing opportunities and in the AER, some standardised indicators on economic performance are proposed. The indicators used in the AER (e.g. gross revenues, gross value added, net profit) are considered to be suitable to value the fishery outcomes in the first instance and with that, the value of the exploitation of commercial species. At a later stage other more direct economic indicators on the value of the stocks, such as the net present value of the commercial species or the resource rent could also be considered.

3) – Discuss available and reliable modelling approaches applied to describe ecosystems, particularly EcoPath, Ewe and EcoTroph and bio-economic models.

STECF notes that several hundred ecosystem models have been built in the world, using the Ecopath and/or Ecosim software (EwE)3. Some of them, related to European ecosystems, considering very heterogeneous scales (from small costal areas to the whole North Sea). Undoubtedly, such models may contribute to the understanding of relationships between species or groups and of the trophic ecosystem functioning. They often provide useful diagnoses on the current state of ecosystems and a synthetic overview on the knowledge we have on the specific case under study. At the same time, it is generally admitted that such models have a limited power to make forecasts and if so with a high level of uncertainty. EwE models have been used to explore scenarios, including management options, and to analyse the ecological consequences on all the biological compartments. On the other hand, such models have for the moment never been used in any mandatory working groups in charge of the scientific advice. Usefulness of this approach in the management process therefore still needs to be tested and demonstrated.

EcoTroph (ET)4 is a more recent approach, providing a simplified representation of the ecosystem functioning and a way to estimate production functions and to make diagnoses of fishing impact at the ecosystem level. Even if this approach according to the developers is considered to be promising, it is recognised that little experience has been accumulated on its usefulness for management purposes.

With respect to bio-economic models, STECF notes that the report on the review on bio-economic models (Prellezo et al, 2009) provide a good overview on the current state of the art of bio-economic modelling and a framework to select models based on objectives and data availability. None of these models has been developed to consider questions related to the ecosystem. However, STECF considers that in specific cases where multi-species multi-fleet analyses are requested, adjustments to the models might be small, whereas in order to develop more complete ecosystem bio-economic models considerable resources will be needed.

STECF notes that besides these models, the F-cube approach has been developed in order to model effects of management measures in a multi-species/multi-fleet context (Ulrich et al., 2006, CIEM 2006). Based on assumptions on the behaviour of fishermen (optimising TAC uptake of all species or target species, maximising sea days), this model predicts *inter alia* catches of each species by each fleet, the implied fishing mortalities and the resulting SSB. However, the economic part of this model is very limited and no conclusions can be drawn on the economic effects of the imposed management measures.

STECF concludes that based on the current information, no selection can be made of the preferable bio-economic models to be utilised. More information is needed with respect to the specific needs for a model, such as region, type of management restrictions, number of species and involved fleets.

More generally, a common standard model taking into account all the complexity of an ecosystem, including both ecological and economic dynamics, currently does not exist or has emerged from the scientific community as a consensual tool. Several models are likely to be built on each ecosystem providing different views of its functioning and dynamic. STECF notes that complementarities exist between trophodynamics approaches such as EwE or ET, and bio-economic models. It is likely that both approaches could be usefully used in parallel.

STECF considers the three kinds of tools mentioned above is a way to look at the current trade-off between economic profitability and ecosystem impact. Integrated assessment tools deals with the impact on targeted stocks (which is part of ecosystem approach), while indicators are related to the ecosystem level, providing tools to assess the impact of fishing on the various biological compartment of an ecosystem, but also on habitat, or on emerging properties of ecosystems (productivity, stability, resilience, …). Bio-economic and ecological models should especially be used to explore the consequences, in term of fisheries profitability (and hence fishermen behaviour and dynamics) and ecosystem impact, of various management options.

STECF recommendations

Based on the above considerations, STECF recommends that:

- In order to set out a roadmap to further consider the possibilities for implementing an ecosystem approach, a STECF subgroup should be set up under the auspices of STECF-SGMOS, with participation of ecologists, biologists and economists.

- [3] Polovina 1984; Christensen and Pauly 1992; Walters *et al.* 1997
- [4] Gascuel 2005; Gascuel *et al* .2009

- It is recommended to devise the development of such a decision support system in three steps.
    - In the first step a fisheries information system should be devised. This system, based on marinographic area, should bring together existing data on fish stocks, ecosystem indicators and economic data. For each area an analysis of available and lacking data should be made. Based on this data, ecosystem indicators can be developed.
    - In the second step for each marinographic area an appropriate set of analytical tools (models) should be devised based on the characteristics of the ecosystem and economic system. It is advised that a preparatory group will prepare a comprehensive overview of available models and applicability to given circumstances. Development of ecosystem models and bio-economic models can be set up parallel, with the bio-economic models evolving from multi-species models on commercial species to models that include both direct and indirect effects (ecosystem interactions) on commercial and non-commercial species.
    - In the third part the data base and models should be brought together in a Decision Support System: a data and modelling environment capable of providing an *ex-ante* impact assessment of proposed management measures on the ecosystem and the economic system.

- A pragmatic first step should be taken to use the tools described in relation to question 1 above, to show changes in the biological status of the species and to include economic information in the assessment.

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APPENDIX 3 - ECOSYSTEM INDICATORS

1- Conservation status of fish species

From this list of possible indicators the conservation status of vulnerable fishes is an indicator that directly reports on the condition of vulnerable fishes and is immediately operational on the basis of current data collection. Furthermore by focusing on the large fish in the community it focuses on the portion of the fish community most impacted by fishing. The conservation status of fishes is obviously limited to the fish community and gives no information on the impact of fishing on other ecosystem components, however as noted by the EC (2008) 187 there is currently insufficient data collection to allow similar indicators to be implemented for mammals, reptiles or seabirds.

1.1. Methodology

According to EC (2008) 187 two indicators of the biodiversity of vulnerable fish species can be calculated from data compiled according to the preceding process: (CSFa) an indicator of the biodiversity of vulnerable fish species that responds to changes in the proportion of contributing species that are threatened and (CSFb) an indicator of the biodiversity of vulnerable fish species that tracks year-to-year changes in the abundance of contributing species. Both indicators assume that the survey catch rate provides an index of abundance.

Calculation of the "Conservation Status of Fish" (CSF) indicators is based upon fishery independent trawl survey data that reports CPUE of species by length. This data is available from surveys conducted under the DCR/DCF. The North Sea IBTS survey provides coverage of the whole North Sea area as a single co-ordinated survey and can provide the information required to calculate the CSF indicators. The North Sea IBTS survey data were available from DATRAS to calculate the indicator in this report. The time period used was all data from 1983 until 2007. 1983 was chosen as the first year in the time series to use as this was the first year in which all component parts of the IBTS survey were conducted with a GOV trawl; 2007 was the latest available data at the time of this work.

The calculated indicators shown in this report are based on the work done in the MEFEPO project and reported in (Le Quesne 2010). The following modifications were made to the method described in EC (2008) 187:

- For each species and each survey time series L_{max} observed in the survey time series was used instead of L_{inf}. This allows the indicator to be applied over a wide range of areas, as the L_{inf} for a species reported in wider literature may be from a different area or region and inappropriate for the location where a specific survey is conducted.
- Both CSFa and CSFb were calculated compared to a reference period. According to the procedure in EC (2008) 187 the reference period for CSFa is the first year of the time series, whereas for CSFb the reference period is the average of the first three years of the time series. Within this assessment CSFa was also calculated using the first three years of the time series as the reference period to examine the influence this had on indicator behaviour. This avoided CSFa being skewed by a single years' data, and also reduced the incidence of zero abundance for a given species in the reference period that hinders calculation of relative abundance.
- The first step in calculating CSF is to develop a list of species to include in indicator calculations. One of the criteria for inclusion in the list is a minimum abundance threshold. Species that are declining, or disappear, over the time series may fail to reach the minimum abundance threshold when considered over the whole time series. As these are the very species that are most in need of consideration from a biological diversity point of view it seems undesirable that they are excluded from indicator calculations. The method specified in EC (2008) 187 is for the average abundance over the whole time series to be considered when compiling the species list. In this study an alternative criterion was developed to construct the species list by just considering the average abundance over the first three years of the time series.
- When considering the annual abundance of a species, only individuals larger than $L_{max}/2$ are included in the calculations to reduce the noise from young age groups with variable abundance. In surveys where the observed L_{max} is particularly large compared to the length distribution of species observed in the time series this will lead to an abundance of 0 being reported for many years. In specific cases where this occurred the minimum length for consideration was reduced to half of the quartile $0.75L_{max}$ rather than half of L_{max}.
- An alternative species list was used to calculate the indicators and was based on the average abundance of species during the first five years of the time series as opposed to over all years of the time series as indicated in EC (2008) 187. This alternative method for calculating the species list was applied to avoid a 'shifting baseline' as it was noted that species that were declining over time could be excluded from the list due to failing to meet the minimum average annual abundance requirement of 20 individuals being present each year even if they achieved the abundance requirement over the early period of the time series. The two comparative species lists are listed in table 2.1.1, the indicators were calculated using both species lists, the 'full list' and the '5 year list'. The criteria for including species in the species list required that the maximum length was over 40cm, and species could be further excluded if "*they have morphology, behaviour or habitat preferences that are expected to lead to low and variable*

catchability in the survey gear." The species that were excluded due to limited or variable sampling are listed in table 2.1.2 along with the reason for exclusion.

Table A2.1 Species included in the original species list and species included in the list based on the first 5 years of records. A '1' indicates that the species was included in the list.

Species	Common names	Full list	5 year list
Anarhichas lupus	Wolf fish		1
Gadus morhua	Cod	1	1
Leucoraja naevus	Cuckoo ray	1	1
Lophius piscatorius	Angler fish	1	
Pollachius virens	Saithe	1	1
Squalus acanthias	Spurdog		1
Amblyraja radiata	Starry ray	1	1
Merluccius merluccius	Hake	1	
Melanogrammus aeglefinus	Haddock	1	1
Merlangius merlangus	Whiting	1	1
Pleuronectes platessa	Plaice	1	1
Lepidorhombus whiffiagonis	Megrim	1	
Cyclopterus lumpus	Lumpsucker	1	1
Glyptocephalus cynoglossus	Witch	1	1
Microstomus kitt	Lemon sole	1	1
Entelurus aequerius	Snake pipefish	1	
Enchelyopus cimbrius	Fourbeard rockling	1	1
Eutrigla gurnardus	Grey gurnard	1	1
Solea vulgaris	Common sole	1	1
Trachurus trachurus	Horse mackerel	1	
Hippoglossoides platessoides	Long rough dab	1	1

Table A2.2: Species meeting length and abundance criteria excluded from final species list due to variable sampling or other reasons.

Species name	Common name	Reason for exclusion
Platichtys flesus	Flounder	Strong estuarine affinity, limited sampling
Alosa fallax	Twaite shad	Anadromous, limited sampling in survey
Scomber scombrus	Mackerel	Shoaling, variable catchability
Spinachia spinachia	Fifteen-spined stickleback	Presumed mis-identification or mis-recorded in records, unlikely to reach 40cm

1.2. North Sea results

- CSFa, IUCN criteria

CSFa is the conservation status indicator calculated with reference to the IUCN threat criteria. Four versions of the indicator were calculated (Figure 2.1.1), using the full or 5 year species lists, and using just the first year as the reference abundance, or the first three years as the reference abundance. EC (2008) 187 suggested a value of 1 as a limit reference point, this equates to all the species in the list being considered 'vulnerable'. It should be noted that as this is the average IUCN threat status of species in the list, a single species could become 'critically endangered' or even lost from the system without the indicator value reaching the limit threshold.

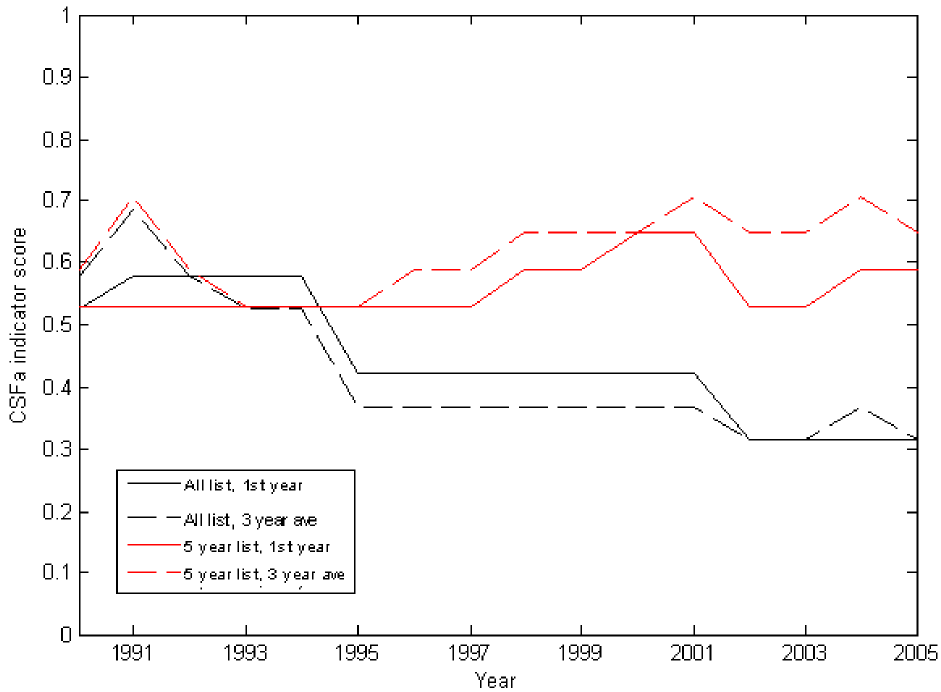

Figure A2.1: CSFa indicator values calculated with the full and 5 year species lists, and using either the first year or average of the first three years as the reference period. From the MEFEPO project (Le Quesne 2010).

The indicator value for the CSFa, calculated with either the full or 5 year species list, and with either just the first year, or the average of the first 3 years as the reference period is shown in figure 2.1.1.

There is variation in the quantitative and qualitative performance of the indicator depending on the species list chosen and the reference period used. When the full species list is used there is a decline (improvement in conservation status) in the indicator value over the full survey period, irrespective of the reference period chosen. Conversely when the 5 year species list was used the indicator value increased (decline in conservation status) over the full survey period, irrespective of the reference period used. However in all cases the indicator values remain below the suggested threshold of 1.

- CSFb, relative abundance

CSFb is a conservation status indicator that reports the average abundance of the large fish community on an annual basis in relation to reference period. The reference period is the average abundance over the first three years of the time series. The CSFb indicator was calculated using both the full species list and the 5 year species list (Figure 2.1.2). No reference limits have been suggested, a reference direction of an increase in the indicator value was suggested by EC (2008) 187.

As with CSFa, there is variation in quantitative and qualitative behaviour of the indicator depending on the species list used to calculate the indicator. When the full species list is used the indicator reports a greater than 80% increase in the average biomass of large vulnerable fish compared to the reference period, whereas when the 5 year species list is used the indicator reports an approximately 20% decline in the average biomass of large vulnerable fish compared to the reference period.

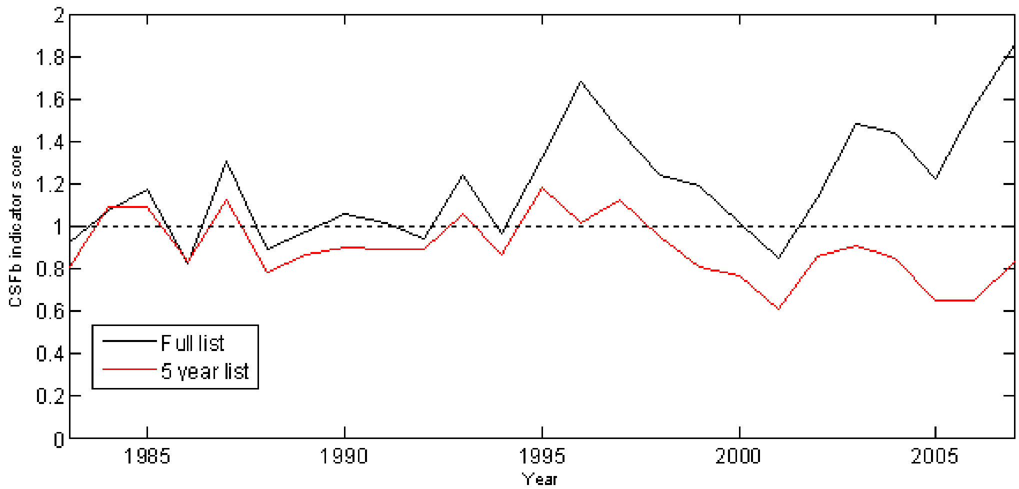

Figure A2.2: CSFb indicator values calculated with the full and 5 year species lists. The dashed line is a reference line with a value of 1. From the MEFEPO project (Le Quesne 2010).

1.3. Discussion

The underlying cause of the variation in behaviour of CSFa and CSFb between the full list and 5 year list is apparent when the abundance trends of the individual species incorporated in the indicator are examined (Figure 2.1.3). Two species, *Anarhichas lupus* and *Squalus acanthias*, that were incorporated in the 5 year list were not included in the full list. Both these species started at low abundance and declined further over time. Whereas five species were included in the full list that were not included in the five year list. In each case these were species that were increasing over the survey time period. Their abundance over the first 5 years was insufficient to allow the species to be included on the basis of abundance, but their increased numbers over time meant that they do achieve the abundance threshold over the full time series. The increased abundance of some of these species may be climate driven, rather than a fishing effect.

The variation in behaviour of the CSF indicators, and the underlying explanation of this behaviour, found in this study indicates that the species list selection criteria developed in EC (2008) 187 should be reconsidered and potentially revised. The approach trialled in this report of basing the species list on the first five years of records holds merits. This method does have the drawback that the indicator could become anchored on a historic 'outdated' community description if climate leads to a change in the 'natural' community inhabiting the area of study. Despite this drawback anchoring the indicator has the merit of avoiding the shifting baseline problem that inherently besets the current species selection criteria.

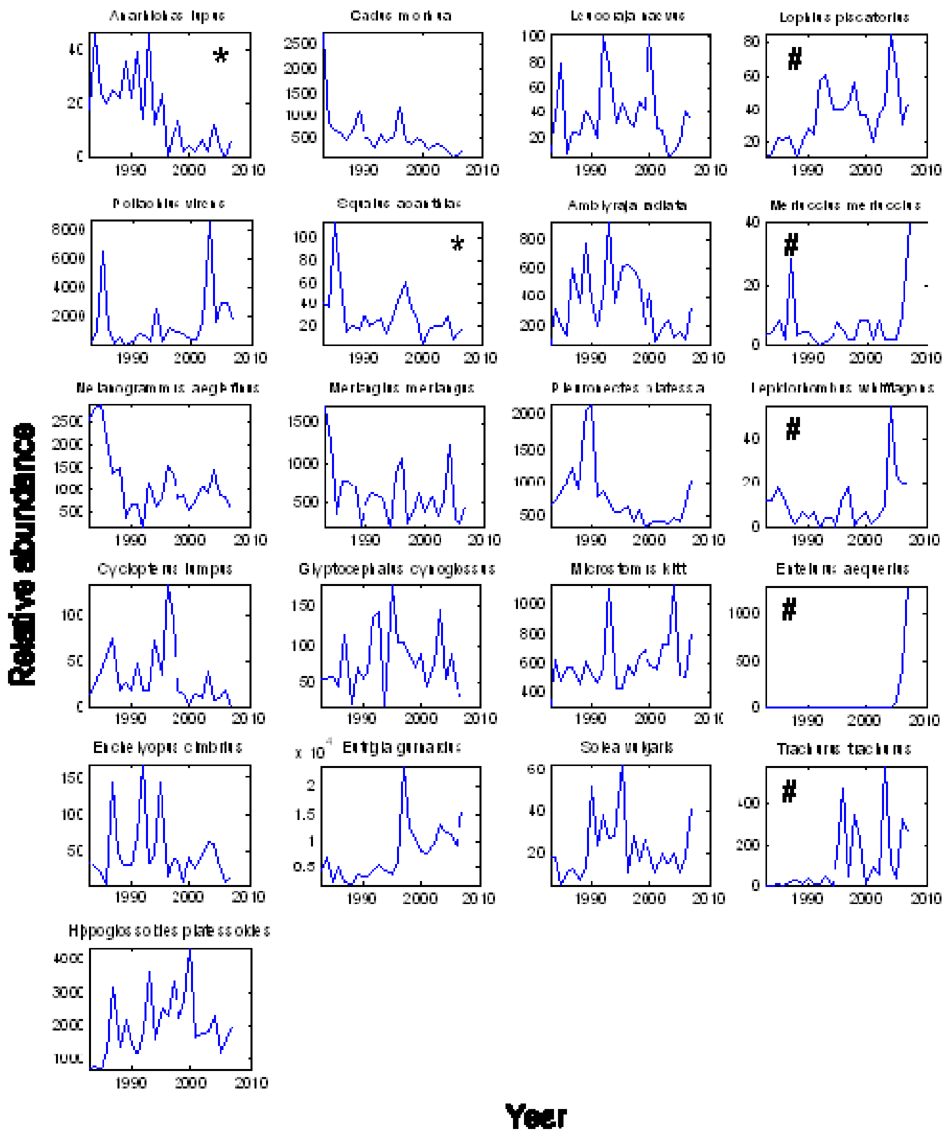

Figure A2.3: Relative abundance over time of all species included in the CSF species lists. All species co-occurred in both lists, apart those marked * which only occurred in the 5 year list and those marked # which only occurred in the full list.

2 - Proportion of large fish

According to EC (2008) 187 the proportion of “large fish” or large fish indicator (LFI) is calculated as:

$$P_{>40cm} = \frac{W_{>40cm}}{W_{Total}}$$

where $W_{>40cm}$ is the weight of fish greater than 40 cm in length and W_{Total} is the total weight of all fish in the sample.

The indicator trend from 1983 (the start of consistent Q1 IBTS) up to 2008 was calculated by (ICES 2009)and is summarized in Figure 7.1.1. This figure shows that at its lowest point in 2001, the indicator fell to a value of 0.05, but it has subsequently recovered in 2008 to a value of 0.22. The indicator, however, is still below the target level of 0.3.

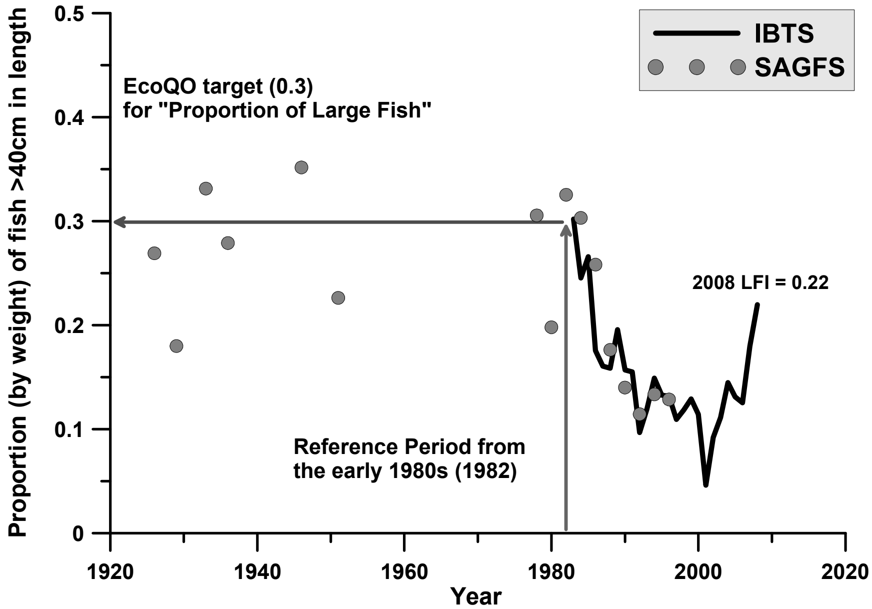

Figure A2.4. Variation in the LFI, which is based on the Q1 IBTS. Stock assessments in the early 1980s suggested that stocks were not being overexploited at that time and that therefore fishing was at sustainable levels. The early 1980s were therefore considered to be a "reference" period, and the LFI recorded at that time deemed to be an appropriate level for managers to aspire to. The EcoQO is therefore 0.3; an LFI value consistent with individual stock conservation and preservation of the integrity of the wider demersal fish community, and yet a level that should still allow a viable fishing industry to persist. Analysis of the Scottish August Groundfish Survey (SAGFS), which stopped in 1997, confirms that an LFI value of 0.3 is an appropriate target for management. The SAGFS LFI tracks the IBTS Q1 index remarkably well over the period that the two surveys coincided, while the earlier index values varied around 0.29.

Some new analyses of ICES Q1 IBTS data were carried out by (ICES 2009) to examine whether the relative extent to which changes in the proportion of large fish indicator are driven by changes in the biomass of fish >40cm in length, believed to be primarily influenced by variation in fishing pressure, or by changes in the biomass of fish ≤40 cm, which are primarily influenced by recruitment events.

These new analyses showed a clear and relatively steady decline in the biomass of large fish from 1983 through to 2001. But between 1983 and 1995, the biomass of small fish doubled, and it was this rapid expansion in the biomass of small fish, combined with the decline in large fish, that was responsible for the initial sharp drop in the proportion of large fish indicator at the start of the time-series. During the 1990s, much of the year-to-year variation in the indicator was driven by variation in the biomass of small fish. Marked peaks in small fish biomass were evident in 1993, 1996 and 2001, coinciding with especially low points in the indicator trend. From 2001, a decline in the biomass of small fish, combined with an increase in the biomass of large fish, particularly since 2006, has been responsible for the recovery in the proportion of large fish indicator. Another point of note is that variation in the biomass of small fish was heavily influenced by changes in the biomass of some species (e.g., whiting) that never (or rarely) grow to a length where they eventually influence variation in the biomass of large fish. Changes in the abundance of such species will always therefore represent environmentally driven noise in proportion of large fish indicator. It can therefore be considered to remove such species in order to improve the signal-to-noise ratio of the indicator. This may, however, also have consequences for the target reference value.

Given that the indicator is a ratio metric, it is clear that variation in the indicator value, as illustrated in the discussion above, is influenced by variation in the abundance of fish both larger and smaller than the 40 cm bound. Relating variation in the indicator value directly to variation in the biomass of fish both larger and smaller than 40 cm, however, confirmed its greater sensitivity to the former (ICES 2009) confirming the appropriateness of the LFI to show changes in the larger sized fish affected by fishing.

3 - Mean maximum length of fishes

According to EC (2008) 187 the Mean maximum length indicator (MMLI) can be calculated for the entire assemblage that is caught by a particular gear or a subset based on morphology, behaviour or habitat preferences (e.g. bottom-dwelling species only).

Mean maximum length is calculated as:

$$\overline{L_{\max}} = \sum_j (L_{\max j} N_j) \Big/ N$$

where $L_{\max j}$ is the maximum length obtained by species j, N_j is the number of individuals of species j and N is the total number of individuals. Asymptotic total length (L_∞) is preferred to maximum recorded total length if an estimate is available, but it is recognised that such data may not be available for many species.

(ICES 2009) calculated the mean ultimate body length (similar to the mean maximum length but based on Asymptotic total length (L_∞) as opposed to $L_{\max}$) according to

$$L_\infty = \frac{\sum_{s=1}^{S} \sum_{n_s=1}^{N_s} l_{\infty,s}}{N}$$

Where l∞,s is the von Bertalanffy ultimate body length of each species s. S is the total number of species recorded in the sample and Ns is the total number of individuals of each species caught. N is the total number of individuals recorded in the sample.

The indicator trend from 1983 (the start of consistent Q1 IBTS) up to 2008 was calculated by (ICES 2009)and is summarized in Figures xx and xx for the North Sea and Kattegat and Skagerrak separately. The North Sea figure shows two peaks, one in the late eighties, the other in the early 2000s but no clear trend over time. In contrast the figure for the Kattegat and Skagerrak does show a trend indicating a decline in K-selected species (large maximum size, slow maturing).

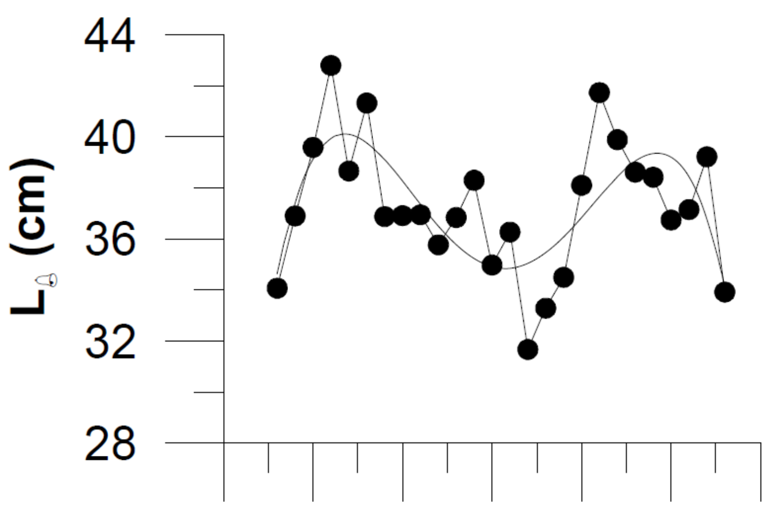

Figure A2.5. Time-series of the Mean maximum length indicator (MMLI) applied to the IBTS Q1 groundfish survey data from 1983 (the start of consistent Q1 IBTS) up to 2008. At its lowest point in 2001, the indicator fell to a value for the whole North Sea. Results based on (ICES 2009).

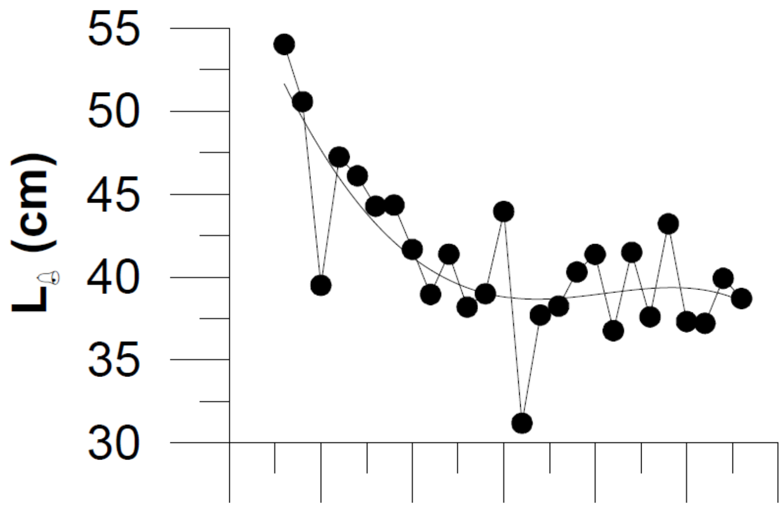

Figure A2.6. Time-series of the Mean maximum length indicator (MMLI) applied to the IBTS Q1 groundfish survey data from 1983 (the start of consistent Q1 IBTS) up to 2008. At its lowest point in 2001, the indicator fell to a value for the Kattegat and Skagerrak. Results based on (ICES 2009).

4 - Probabilistic maturation reaction norm

The probabilistic maturation reaction norm indicator (PMRNI) is an indicator of the potential “genetic effects” of fishing on exploited populations.

According to EC (2008) 187 this indicator reflecting the probability of maturing is derived from the maturity ogive (i.e., the probability of being mature) and from the mean annual growth at age as:

$m(a,s)=(o(a,s)-o(a-1, s-\Delta s(a)))/(1-o(a-1,s-\Delta s(a)))$

where a is age, s is length, $o(a,s)$ is the maturity ogive, and □$s(a)$ is the length gained from age a-1 to a. Estimation of the probabilistic maturation reaction norm thus requires (i) estimation of maturity ogives, (ii) estimation of growth rates (from length at age), (iii) estimation of the probabilities of maturing, and (iv) estimation of confidence intervals around the obtained maturation probabilities.

- Results North Sea

This indicator is not calculated on a regular basis but two studies exist that show for the North Sea the PMRNI over time for plaice (Pleuronectes platessa) (Grift et al. 2003)and sole (Solea vulgaris) (Mollet et al. 2007).

(Grift et al. 2003)apply the PMRNI in order to disentangle phenotypic plasticity from evolutionary change showing that the reaction norm for age and length at maturation has indeed significantly shifted towards younger age and smaller length. This is attributed to intensive exploitation which may have caused evolutionary changes in the age and length at maturation in North Sea plaice (Fig. xx).

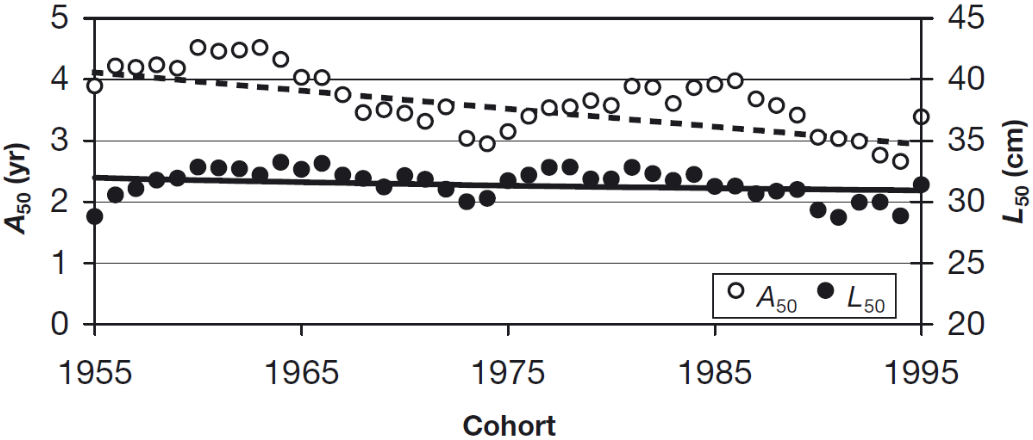

Fig. A2.7. PMRNI for plaice (*Pleuronectes platessa)*. Trends in the age *(A*50) and length *(L* 50) at which 50% of fish are mature in each cohort. Data from logistic models with cohort either as a factor (open and filled circles; R2 = 0.34 and 0.42 for age and length at maturation, respectively) or as a variate (dashed and continuous lines; R2 = 0.30 and 0.40, respectively). In both cases, the decline of *A*50 and *L*50 with time (cohort) is significant ($p < 0.0001$)

Similarly, (Mollet et al. 2007) showed PMRNI of North Sea sole has significantly shifted towards younger age and smaller size.Regression showed that Size at 50% probability of maturation at Age 3 decreased from 28.6 cm (251 g) to 24.6 cm (128 g).

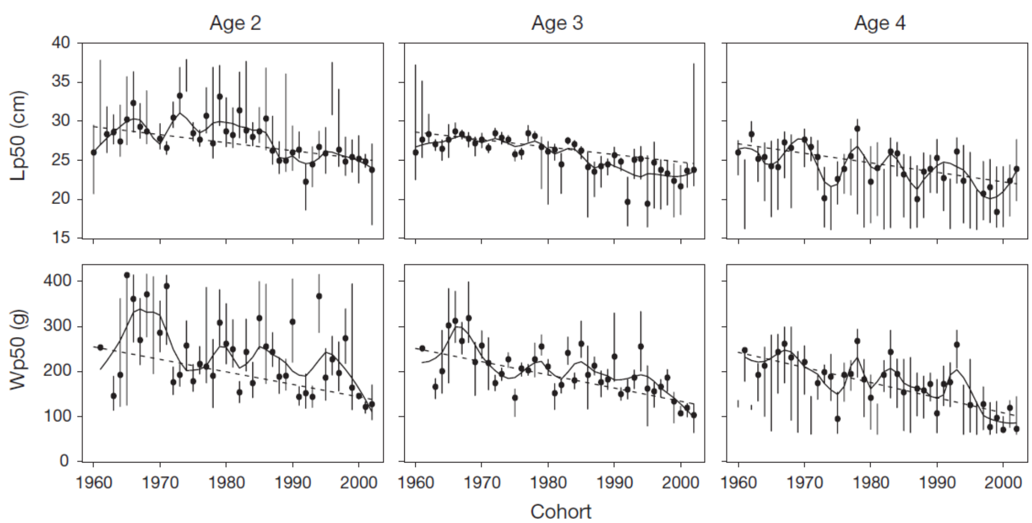

Fig. A2.8. PMRNI for North Sea sole (Solea vulgaris) reaction norm midpoints Lp50 and Wp50 over time (dots), bootstrapped 95% percentiles (vertical bars), trend regression weighted by the inverse bootstrap variances (---) and fit with a non-parametric smoother . All trends are significant on a level of α = 10–4

- Discussion

Fisheries-induced evolutionary changes are unfolding on decadal time scales-much faster than previously thought. Life-history theory predicts that increased mortality generally favours evolution toward earlier sexual maturation at smaller size and elevated reproductive effort. Although alternative causal hypotheses can be difficult to rule out, fisheries-induced evolution consistently arises as the most parsimonious explanation after environmental factors have been accounted for. The question is not whether such evolution will occur, but how fast fishing practices bring about evolutionary changes and what the consequences will be. Life-history traits are among the primary determinants of population dynamics, and their evolution has repercussions for stock biomass, demography, and economic yield. Fisheries-induced evolution may also be slow to reverse or even irreversible, with implications for recruitment and recovery. Consequently, predator-prey dynamics, competitive interactions, relative species abundances, and other ecological relationships will systematically change over time. Current management reference points are thus moving targets: Stocks may gradually become less resilient or may be erroneously assessed as being within safe biological limits. Some evolutionary trait changes will even have the potential to cause nonlinear ecological transitions and other unexpected outcomes. Fisheries-induced evolutionary changes are therefore pertinent beyond single-species management.

5 - Spatial distribution of fishing activities

Three indicators were put forward by EC (2008) 187 to describe the spatial distribution of fishing activities:

Indicator 1: Distribution of fishing activities

Indicator of the spatial extent of fishing activity. It would be reported in conjunction with indicator 2. It would be based on the total area of grids (3km x 3 km) within which VMS records were obtained, each month.

Indicator 2: Aggregation of fishing activities

Indicator of the extent to which fishing activity is aggregated. It would be reported in conjunction with the indicator for 'Distribution of fishing activities'. It would be based on the total area of grids (3 km x 3 km) within which 90% of VMS records were obtained, each month.

Indicator 3: Areas not impacted by mobile bottom gears

Indicator of the area of seabed that has not been impacted by mobile bottom fishing gears in the last year. It responds to changes in the distribution of bottom fishing activity resulting from catch controls, effort controls or technical measures (including MPA established in support of conservation legislation) and to the development of any other human activities that displace fishing activity (e.g., wind farms). This indicator could be reported annually and would state the total proportion of the area by depth strata (0–20 m, 20–50 m, 50–80 m, 80–130 m, 130–200 m, >200 m) in each marine region that has not been fished with bottom gear in the preceding one year period.

In 2009 a tender "Development of tools for logbook and VMS data analysis" (No MARE/2008/10 Lot 2) was launched intended to develop the tools necessary to calculate these indicators in a consistent manner. As this project has not completed the tools are not available and this together with the fact that there are still issues obtaining international VMS data prevented us from calculating these three indicators.

One attempt to calculate one of the indicators using international VMS data, however, was carried out as part of the MEFEPO project and reported in (Le Quesne 2010). In this study the focus was on Indicator 3, the proportion of area not impacted by mobile bottom gears as this was considered to be less affected by the lack of a comprehensive set of international VMS data and provides the most direct measure of the main pressure on benthic systems. The 'proportion of area not trawled' indicator is currently worded such that it is reported by depth strata. This only provides limited resolution of the indicator as numerous distinct benthic habitats can occur within a single depth band. To improve the resolution of the indicator the depth strata were combined with information on sediment type to divide the assessed area into 'habitats' defined by depth and sediment type. The VMS data were used to create a map of effort by mobile bottom gears, to calculate the indicator this was then linked to bathymetry data or a sea floor habitat map. The only available seafloor habitat map with complete coverage of the North Sea RAC area is the sediment map contained in the United Kingdom Digital Marine Atlas, freely available from the BODC (www.bodc.ac.uk). This habitat map was combined with the bathymetry to allow the indicator to be reported for seafloor habitat type by depth band. The indicator was also calculated just using the DCR specified depth bands.

The proportion of area not impacted by mobile bottom indicators was calculated on the basis of VMS records. The first step is to process the VMS data to create a map of fishing effort by mobile bottom gears. This is then overlaid over a bathymetry chart, and if available a habitat map, and the final indicator of the proportion of area not trawled by depth band and habitat type calculated. The VMS processing method used is the 'point summation method' as developed by (Lee et al. 2010). More detail on the methodology is provided in {Le Quesne, 2010 #6964}. The indicator assessment is based on VMS data for 2006 and 2007.

- Results North Sea

The proportion of area not trawled, by depth and habitat types, was calculated from the map of effort by mobile bottom gears compiled within this project (Figures 2.4.1 & 2.4.2). The lower reported effort in Norwegian waters compared to the other areas for which data is available can mainly be attributed to data collection. The Norwegian data is only based on Norwegian vessels over 24m, whereas for the other areas the data includes all vessels, national and foreign, over 15m.

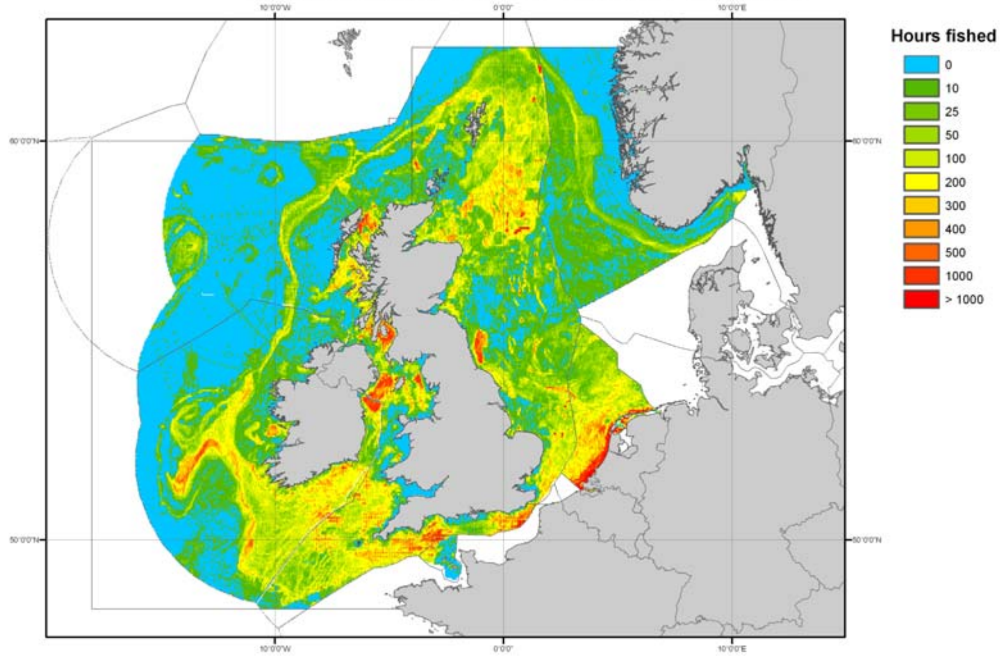

Figure A2.9. Distribution of fishing effort by mobile bottom gears for 2006 by 3'x3' cells based on VMS records from submitting nations. The VMS data were processed using the point estimation method described above.

The proportion of area not trawled indicator was calculated for 2006 and 2007 by depth band and sediment type (Table 2.4.1 and 2.4.2).

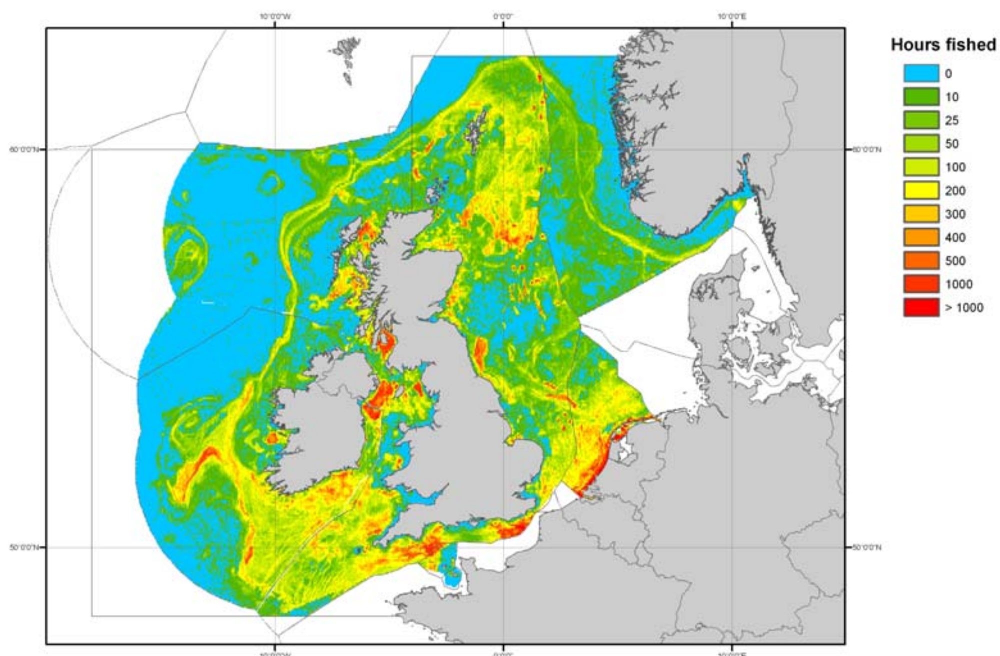

Figure A2.10 Distribution of fishing effort by mobile bottom gears for 2007 by 3'x3' cells based on VMS records from submitting nations. The VMS data were processed using the point estimation method described above.

Table A2.3 Percent of area not impacted by mobile bottom gears by combined depth band and sediment type For the North Sea RAC region for 2006. Blank cells for areas where the sediment type did not occur in that depth band. See text for details.

		Depth					
		>200m	130 to 200m	80 to 130m	50 to 80m	20 to 50m	0 to 20m
Habitat	Mud	47	33	37	41	4	8
	Sand	48	41	42	47	19	26
	Mud and Sand	50	15	39	39	24	48
	Mud and Gravel	46	48	9	22		
	Sand and Gravel	45	36	42	44	26	33
	Mud, Sand and Gravel	49	21	33	48	12	5
	Rock, Gravel and Sand	49	40	43	42	26	26

Table A2.4. Percent of area not impacted by mobile bottom gears by combined depth band and sediment type For the North Sea RAC region for 2007. Blank cells for areas where the sediment type did not occur in that depth band. See text for details.

		Depth					
		>200m	130 to 200m	80 to 130m	50 to 80m	20 to 50m	0 to 20m
Habitat	Mud	47	29	37	41	4	7
	Sand	48	41	44	47	21	26
	Mud and Sand	48	19	40	39	25	45
	Mud and Gravel	45	38	0	28		
	Sand and Gravel	44	34	44	44	27	34
	Mud, Sand and Gravel	48	22	32	49	18	4
	Rock, Gravel and Sand	49	40	43	42	26	27

The calculation of the indicator values for 2006 and 2007 per combined depth band and sediment type shows there are considerable differences between habitats/depth bands ranging from 4% to 50% unfished in 2006 and 0 to 49% in 2007. There appears to be high consistency between years but as this was only done for two years it was not possible to show any changes of the indicator over time.

- Discussion

A primary concern with an indicator based on VMS records is that this takes no account of the <15m fleet. This is likely to be of particular importance in inshore and coastal areas. The high proportion of <20m and 20-50m waters reported as not trawled for some sediment types (Table 2.4.1 & 2.4.2) could be a biased estimate. Further work needs to be developed on assessing the distribution of fishing effort by the <15m fleet and integrating this information with the VMS records from the >15m fleet.

It is important to consider the issue of spatial scale of analysis when interpreting the indicator results, and the implications this has for sea floor integrity. The spatial scale of analysis can significantly alter conclusions as to the proportion of area not trawled (Piet & Quirijns, 2009). A smaller spatial scale of analysis results in increased perceived patchiness of trawl impacts, and thus increases the proportion of area not impacted.

The extent and frequency of impact that different benthic habitats can withstand before becoming functionally degraded will vary between habitat types and the type of bottom gear used. Given the uncertainties involved it would seem likely that for the next few years management decisions relating to maintaining benthic habitat functioning will have to be based on informed opinion. Once these limitations are accepted VMS data can play an important role in understanding, and monitoring, the distribution of fishing effort by vessels deploying mobile bottom gears. Understanding the impact of fishing on benthic ecosystems requires not only knowledge of the distribution of fishing effort, but also the composition and distribution of benthic habitats. Currently there are no reliable seafloor habitats maps that cover whole RAC areas, let alone the whole European shelf seas. Improved mapping of European seafloor habitats is an essential activity to allow GES to be defined and monitored. Improving the coverage of vessels required to carry VMS, and increasing the VMS position reporting frequency, would both act to improve assessment of impact of mobile bottom gears on benthic ecosystems. The protocols for sharing VMS data outputs across nations need to be developed to allow calculation of the indicator to occur on a regular basis.

A further comment needs to be made about the proportion of area not impacted by mobile bottom gears as specified in EC (2008) 187; the current definition of this indicator is that it should be reported as the area not impacted by mobile bottom gears on an annual basis. Recovery time of benthic habitats to impacts of mobile bottom gears varies depending on the type of habitat and gear used, and can vary from hours and days to years and decades (Jennings & Kaiser, 1998). Reporting the indicator on an annual basis is sufficient to understand the impacts of fishing on sea-floor habitats where the recovery time from the disturbance is less than one year. However for habitat-gear combinations where the recovery time is greater than a year, reporting the indicator on an annual basis and only considering the previous years fishing will underestimate the extent of impact. The time period over which VMS records incorporated for calculating this indicator should be reassessed to ensure it is sufficient to allow for the prevalent recovery time with regard to the sea-floor functions of concern.

Conclusion

The work presented here shows at least one of these indicators can be calculated if international VMS data and the tools to calculate these indicators in a consistent manner become available. If it is concluded that the indicator(s) benefit from including habitats as opposed to only depth bands then improved mapping of sea-floor habitats would improve the resolution of the indicator(s).

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Le Quesne WJF, Frid, C. L. J., Paramor, O. A. L., Piet, G. J., Rogers, S. I., and Velasco, F. (2010) Assessing the impact of fishing on the Marine Strategy Framework Directive objectives for Good Environmental Status. Developing and testing the process across selected RAC regions: the North Sea.

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Levin SA (1992) The Problem of Pattern and Scale in Ecology. Ecology 73:1943-1967

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Piet GJ, Quirijns F (2009) Spatial and temporal scale determine our perspective of the impact of fishing Canadian Journal of Fisheries and Aquatic Science 66:829–835

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Appendix 4 – Stock synthesis: main data used in the Celtic Sea

Table 4.1. Time series of stock status indicators for the Celtic Sea

	Landings (tons)			mean F			SSB			Recruitment index		
	9 stocks	4 stocks	5 stocks	4 stoc.	9 stoc.	5 stoc.	9 stocks	4 stocks	5 stocks	9 sto.	4 sto.	5 sto.
1972		94795		0.395							0.49	
1973		112243		0.436				633861			0.67	
1974		108989		0.415				621205			0.48	
1975		130306		0.478				580863			0.69	
1976		131920		0.467				532376			0.68	
1977		98654		0.409				483197			0.44	
1978		115099	134404	0.369		0.363		459898			0.59	0.80
1979		133908	153642	0.437		0.425		454389	537212		0.81	0.95
1980		124580	146615	0.461		0.415		393005	491029		1.02	1.20
1981		134477	155498	0.505		0.450		335005	427986		1.03	1.12
1982	184004	123272	144722	0.412	0.485	0.390		343463	444191	2.07	0.77	0.85
1983	204062	130115	152540	0.445	0.553	0.413	1036883	350887	452706	1.03	1.02	1.06
1984	201655	124546	149233	0.438	0.525	0.381	1089579	410164	507997	1.16	1.17	1.15
1985	194531	116083	137962	0.359	0.434	0.356	1067455	410435	514417	1.03	0.91	0.96
1986	217037	121407	143676	0.433	0.498	0.406	1558012	404969	546892	1.22	0.79	0.84
1987	247442	129349	154075	0.488	0.581	0.401	1890480	412777	543730	1.77	1.88	1.72
1988	267038	134053	159325	0.406	0.481	0.387	2165457	415666	525483	1.04	1.02	1.04
1989	294403	126084	152019	0.459	0.515	0.422	2395641	419541	507968	0.74	0.80	0.85
1990	327293	119997	145074	0.501	0.554	0.429	2265679	433236	513032	0.88	0.93	1.01
1991	314371	130598	151034	0.501	0.577	0.440	1952169	403485	469070	1.00	0.86	0.91
1992	337503	138352	160426	0.519	0.553	0.437	1901328	419639	472763	1.30	1.37	1.35
1993	372598	145411	165730	0.465	0.500	0.414	1672776	426889	472853	1.07	0.82	0.88
1994	357173	145601	165608	0.465	0.480	0.453	1607210	408177	452423	1.19	1.24	1.18
1995	409906	142050	164514	0.528	0.528	0.447	1432657	393424	434570	1.08	1.07	1.07
1996	322667	111377	129785	0.467	0.459	0.436	1277477	421943	464214	0.84	0.84	0.88
1997	346733	113682	130296	0.520	0.508	0.460	1271233	420727	461514	0.90	0.94	0.92
1998	292521	123631	137281	0.529	0.526	0.474	1257263	424172	466179	0.74	0.75	0.75
1999	277634	117734	133256	0.559	0.588	0.468	1233927	400263	440574	1.01	1.22	1.15
2000	242234	128222	144602	0.500	0.528	0.433	1297169	398269	437610	0.89	1.05	1.00
2001	243881	127991	142304	0.487	0.531	0.413	1282374	356179	396700	1.17	0.99	0.94
2002	236670	126373	142012	0.472	0.493	0.413	1058546	344834	388643	0.92	1.14	1.07
2003	220187	112893	129741	0.490	0.490	0.419	1166044	299618	344659	0.57	0.54	0.63
2004	202991	108546	126642	0.467	0.466	0.387	1146145	289638	335687	0.69	0.75	0.81
2005	196019	89677	107812	0.417	0.458	0.330	1246214	299285	349488	0.86	1.14	1.11
2006	168421	77430	93615	0.337	0.393	0.310	1611701	372630	422310	0.66	0.72	0.82
2007	172480	93981	111570	0.356	0.447	0.298	1621351	392828	446059	0.82	0.75	0.79
2008	178829	95781	114423				1522393	400465	452206			

4 stocks: cod, herring, mackerel and sole Viifg; 5 stocks: + hake; 9 stocks: + horse mackerel, plaice (VIIe and VIIfg), whiting.

Table 4.2 Reference points used to calculates the stock status for the last year assessed by stock in the Celtic Sea

	stock	Fpa	Bpa	F0.1	SSB0.1	last year
cod	cod-7e-k	0.68	8800	0.233	21982	2007
plaice fg	ple-celt	0.45	1800	0.125	3614	2009
plaice 7e	ple-echw	0.45	2500			2009
Sole fg	sol-celt	0.37	2200	0.123	7460	2009
whiting	whg-7e-k	0.65	21000	0.231	41266	2009
L pisc	anp-78ab	0.24	31000	0.054	296387	2004
Hake	hke-nrtn	0.25	140000	0.104	327657	2009
Megrim	mgw-78	0.3	55000	0.100	166129	2004

Table 4.3 Time series of B* and F* for the Celtic Sea

	used in the report				additional time series			
	2 stocks (1)		5 stocks (2)		7spp (3)		b5stocks (5)	
	F*	B*	F*	B*	F*	B*	F	B
1972	0.68	0.24						
1973	0.64	0.11						
1974	0.43	0.10						
1975	0.74	0.08						
1976	0.93	0.05						
1977	0.43	0.02						
1978	0.32	-0.05					0.79	0.05
1979	0.59	0.00					0.93	0.13
1980	0.90	0.11					0.99	0.18
1981	1.12	0.18					1.01	0.17
1982	0.86	0.13	1.29	0.15			1.06	0.17
1983	1.25	0.17	1.50	0.10			1.18	0.15
1984	0.86	0.08	1.43	0.19			1.08	0.19
1985	0.94	0.09	1.14	0.29			0.89	0.31
1986	1.47	0.17	1.26	0.29	1.31	0.24	1.15	0.34
1987	1.58	0.08	1.64	0.32	1.58	0.25	1.40	0.30
1988	1.33	0.37	1.49	0.31	1.43	0.32	1.28	0.32
1989	1.47	0.41	1.56	0.19	1.56	0.26	1.48	0.22
1990	1.82	0.17	1.78	0.12	1.75	0.13	1.74	0.12
1991	1.62	0.01	1.53	0.04	1.58	0.04	1.44	0.02
1992	1.31	0.06	1.40	0.13	1.39	0.10	1.42	0.03
1993	1.31	0.09	1.28	0.26	1.22	0.20	1.29	0.03
1994	1.43	0.07	1.38	0.42	1.29	0.32	1.46	0.04
1995	1.67	0.11	1.63	0.56	1.51	0.44	1.74	0.08
1996	1.65	0.14	1.32	0.52	1.36	0.42	1.55	0.07
1997	1.83	0.09	1.40	0.40	1.41	0.33	1.61	0.04
1998	2.00	0.04	1.38	0.24	1.40	0.21	1.61	0.01
1999	1.75	-0.04	1.55	0.09	1.44	0.07	1.62	0.09
2000	1.22	-0.11	1.26	0.01	1.18	0.01	1.31	0.16
2001	1.39	0.07	1.20	0.15	1.19	0.11	1.20	0.05
2002	1.46	0.20	1.28	0.19	1.28	0.15	1.41	0.00
2003	1.64	0.05	1.26	0.10	1.28	0.05	1.46	0.06
2004	1.18	-0.08	1.12	0.07	1.16	0.01	1.29	0.10
2005	1.04	-0.09	1.15	0.03			1.15	0.12
2006	0.66	-0.12	1.04	0.00			0.92	0.10
2007	0.78	-0.06	1.33	0.02			1.05	0.05
2008			0.97	0.10				
2009			0.97	0.21				

(1) cod and sole; (2) plaice VIIfg, plaice VIIe, sole VIIfg and hake; (3) assemblage 2 + cod, whiting, monkfish (L. piscatorius); (4) plaice VIIfg, plaice VIIe, sole VIIfg and cod

APPENDIX 5 – STOCK SYNTHESIS: MAIN DATA USED IN THE NORTH SEA

Table 5.1. Time series of global indices used to draw the stocks synthesis in the North Sea, computed from 6 and 14 assessed stocks, respectively during the period 1967-2008 and 1984-2007

	landings		meanF		SSB		recruitment index	
	6-stocks	14-stocks	6-stocks	14-stocks	6-stocks	14-stocks	6-stocks	14-stocks
1967	1 449 135		0.529		2 046 034		3.505	
1968	1 583 996		0.627		1 613 016		0.711	
1969	1 962 051		0.654		2 184 095		0.774	
1970	1 997 732		0.694		2 232 078		1.834	
1971	1 782 165		0.697		1 740 873		1.847	
1972	1 644 127		0.651		1 675 354		0.702	
1973	1 452 971		0.697		1 576 205		1.264	
1974	1 324 961		0.709		1 525 501		1.706	
1975	1 409 247		0.811		1 335 295		0.887	
1976	1 332 170		0.829		1 269 222		1.111	
1977	973 140		0.711		1 068 037		1.431	
1978	808 366		0.582		961 119		0.848	
1979	897 113		0.561		965 177		1.396	
1980	1 171 234		0.585		1 019 774		1.754	
1981	1 068 998		0.545		1 168 309		1.120	
1982	1 218 211		0.592		1 289 878		1.374	
1983	1 262 119		0.648		1 423 524		1.381	
1984	1 411 371	4 002 865	0.687	0.596	1 578 135	8 391 196	1.418	1.128
1985	1 521 132	3 900 806	0.715	0.610	1 631 696	9 990 277	1.272	1.116
1986	1 617 760	4 147 354	0.797	0.640	1 587 478	10 358 563	2.545	1.791
1987	1 549 271	4 066 984	0.727	0.613	1 798 956	12 125 323	0.969	0.936
1988	1 566 844	4 199 691	0.753	0.594	2 026 166	12 630 058	1.254	1.058
1989	1 397 567	3 959 701	0.702	0.605	2 025 509	11 241 565	0.847	0.937
1990	1 182 344	3 572 060	0.695	0.586	1 916 154	10 423 535	0.912	1.030
1991	1 162 063	3 709 042	0.650	0.564	1 643 595	10 505 071	0.790	1.032
1992	1 254 477	4 064 171	0.673	0.547	1 340 915	10 546 191	1.410	1.238
1993	1 278 020	3 859 423	0.708	0.540	1 093 387	10 337 405	0.710	0.917
1994	1 175 428	3 877 559	0.659	0.560	1 153 227	9 316 110	1.159	1.258
1995	1 195 771	4 203 543	0.667	0.534	1 121 011	9 057 718	0.952	0.901
1996	850 440	3 447 205	0.646	0.510	1 141 098	9 143 178	0.787	1.084
1997	784 344	3 798 868	0.584	0.532	1 298 082	8 918 243	1.312	1.054
1998	900 793	4 120 777	0.635	0.515	1 455 135	11 073 358	0.538	0.709
1999	828 494	3 881 712	0.641	0.560	1 536 976	11 114 839	1.655	1.280
2000	783 904	4 045 580	0.598	0.555	1 510 081	10 882 489	0.853	0.891
2001	813 869	4 493 630	0.536	0.478	2 166 282	11 345 014	0.786	1.275
2002	786 747	4 229 365	0.445	0.471	2 582 601	12 810 213	0.876	1.064
2003	815 773	4 403 275	0.469	0.447	2 739 011	14 440 190	0.447	0.683
2004	890 892	4 495 266	0.445	0.415	2 743 793	14 617 002	0.479	0.652
2005	969 420	3 910 317	0.440	0.390	2 575 920	15 168 250	0.773	0.793
2006	820 138	3 764 669	0.439	0.391	2 117 474	14 877 836	0.712	0.628
2007	701 808	3 254 291	0.391	0.352	1 747 323	13 368 345	0.544	0.541
2008	574 520		0.361		1 906 005		0.464	

Table 5.2. Reference points of some assessed stocks used to describe the stocks status of the North Sea ecosystem. Note that such information was not available for all 14 stocks used in previous global indices.

		$F_{0.1}$	F_{pa}	$B_{0.1}$	B_{pa}	Ref. year	Ref. report
6-stocks	Cod in Sub-area IV, Divison VIId & Division IIIa	0.13	0.65	565 001	150 000	2008	wgnssk
	Haddock in Sub-area IV and Division IIIa	0.17	0.70	413 531	140 000	2008	wgnssk
	Herring in Sub-area IV, Divisions VIId & IIIa	0.13	0.25	1 639 634	1 300 000	2008	hawg
	Plaice Sub-area IV	0.14	0.6	1 593 695	230 000	2008	wgnssk
	Saithe in Sub-area IV, Division IIIa & Sub-area VI	0.14	0.4	408 626	200 000	2008	wgnssk
	Sole in Sub-area IV	0.08	0.4	83 963	35 000	2008	wgnssk
Additional stocks	Mackerel	0.188	0.23	3 214 680	2 300 000	2008	wgwide
	Sole in Division VIId	0.1	0.4	3 0151	8 000	2008	wgnssk
	Sole in Division IIIa	0.19	0.3	3129	1 060	2008	wgbfas
	Blue whiting	0.18	0.32	33 92 509	2 250 000	2008	wgwide

Table 5.3: Time series of B* and F* computed using the stocks listed in the previous table.

	B*		F*	
	6-stocks	10-stocks	6-stocks	10-stocks
1967	0.053		0.565	
1968	-0.163		0.744	
1969	0.158		1.198	
1970	0.209		1.114	
1971	-0.067		1.612	
1972	-0.087		2.377	
1973	-0.127		2.181	
1974	-0.158		2.283	
1975	-0.277		2.605	
1976	-0.340		1.767	
1977	-0.487		2.344	
1978	-0.540		2.322	
1979	-0.521		2.947	
1980	-0.516		3.025	
1981	-0.459		2.085	
1982	-0.372		0.982	
1983	-0.305		0.937	
1984	-0.239	-0.186	1.221	0.542
1985	-0.228	-0.145	1.185	0.676
1986	-0.282	-0.102	1.242	0.774
1987	-0.227	-0.096	1.443	0.916
1988	-0.070	-0.004	1.709	1.583
1989	-0.105	-0.028	1.972	1.534
1990	0.005	0.038	2.085	1.866
1991	-0.154	0.024	1.861	1.880
1992	-0.275	0.094	1.904	1.671
1993	-0.441	-0.031	1.808	1.661
1994	-0.340	0.002	1.655	1.430
1995	-0.393	-0.073	1.616	1.417
1996	-0.423	-0.109	1.768	1.544
1997	-0.366	-0.092	1.931	1.815
1998	-0.322	-0.029	1.865	1.766
1999	-0.214	0.109	1.879	1.980
2000	-0.251	0.087	1.514	1.409
2001	0.061	0.302	1.360	1.413
2002	0.315	0.533	1.551	1.608
2003	0.375	0.716	1.426	1.562
2004	0.426	0.797	1.315	1.667
2005	0.311	0.747	1.122	1.488
2006	0.050	0.576	0.876	1.558
2007	-0.166	0.338	0.920	1.537
2008	-0.064	0.275	0.900	1.497

APPENDIX 6 - ECONOMIC PERFORMANCE FLEET BY FLEET IN THE CELTIC SEA

ICES Area: Celtic Sea (VIIe-k)
Country: BEL
Gear: TBB
Length: 24-40

Beam trawling for flatfish is the dominant activity in the Belgian fisheries fleet. This activity is characterised by a considerable environmental impact and a high discard rate of bottom-dwelling fish and benthic invertebrates.

Table 3. Belgian beam trawl 24-40m fleet composition and key indicators in 2008

Fleet segment	Number of vessels	FTE (Or total employed)	Days at Sea (1000 days)	Volume of landings (1000 tons)	Value of landings (million euros)	Direct subsidies (million euros)	Total Income (million euros)	Average wage per FTE (1000 euros)	GVA (million euros)	Operating cash flow (million euros)	Investments (million euros)
TBB VL2440	**47**	**245**	**9.6**	**14.4**	**54.6**	**0.9**	**57.0**	**67.4**	**15.7**	**0.0**	**2.2**

The 47 vessels part of the Belgian beam trawl 24-40m fleet represents a total income of 54.6 million Euros. Total gross revenue of the fleet realized in Celtic Sea in 2008 is 10,9 million euros. Total gross revenue of the fleet is 54,6 million euros. **19% of the total value of landings of the fleet comes from the Celtic sea**. In this case, economic data of the whole fleet can not be used as a proxy to describe the economic performance of the fleet operating in Celtic sea.

In 2008, the main species landed in value (part of the gross revenue of the fleet formed by the species) in Celtic sea were Sole (*Solea solea*, SOL:39%), Anglerfish (*Lophiidae*, ANF:15%), Lemon Sole (*Microstomus kitt*, LEM, 7%), Brill (*Scophthalmus rhombus* , BLL: 5%) and Turbot (*Psetta maxima,* TUR: 4%).

Table 4. Main species for the Belgian beam trawl 24-40m fleet in landings values

SPECIES	VALUES (M€)	tonnes	% value (related to tot value of landings in Celtic sea= 10.9 ME)
Solea solea	4.38	400.82	39
Lophiidae	1.65	148.82	15
Microstomus kitt	0.77	180.38	6.9
Scophthalmus rhombus	0.55	71.67	5
Psetta maxima	0.53	46.12	4.8

Contribution of the Belgian beam trawl fleet 24-40 m in Celtic Sea to fishing mortality of the following stocks was thus evaluated through a ratio of the landings of the fleet in weight for the species compared to total landings registered in 2008 for the stock according to 2010 ICES report on stock assessment.

Table 5. Main fish stocks exploited by the fleet

Stock concerned	Reference
Sole in 27.7. h-k	ICES advice 2010 for Sole in Division VIIh–k (Southwest of Ireland) http://www.ices.dk/committe/acom/comwork/report/2010/2010/Sol-7h-k.pdf
Sole in 27.7.e	ICES advice 2010 for Sole in Division VIIe (Western Channel) http://www.ices.dk/committe/acom/comwork/report/2010/2010/sol-echw.pdf
Sole in 27.7 f and g	ICES advice 2010 for Sole in Divisions VIIf and g (Celtic Sea) http://www.ices.dk/committe/acom/comwork/report/2010/2010/sol-celt.pdf
Anglerfish in Divisions VIIb-k and VIIIa,b,d	ICES advice 2010 for Anglerfish in Divisions VIIb-k and VIIIa,b,d (*L. piscatorius* and *L. budegassa*) http://www.ices.dk/committe/acom/comwork/report/2010/2010/whg-7e-k.pdf

Table 6. Catch for BELTBB2440 of the main target species

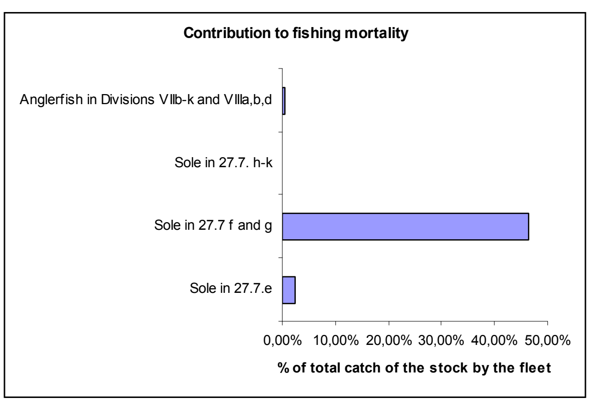
	BEL TBB 24-40 m Volume of landings (tonnes)	ICES catches (landings + discards or estimated highgrading) (tonnes)	**Contribution to fishing mortality (ref ICES Catches)***
Sole in 27.7. h-k	8.96	250 000.00	**0,00%**
Sole in 27.7.e	21.69	910.00	**2,40%**
Sole in 27.7 f and g	370.18	800.00	**46,30%**
Anglerfish in Divisions VIIb-k and VIIIa,b,d	148.82	32200.00	**0,50%**
Other species	2250.11		
Total	2799.76		

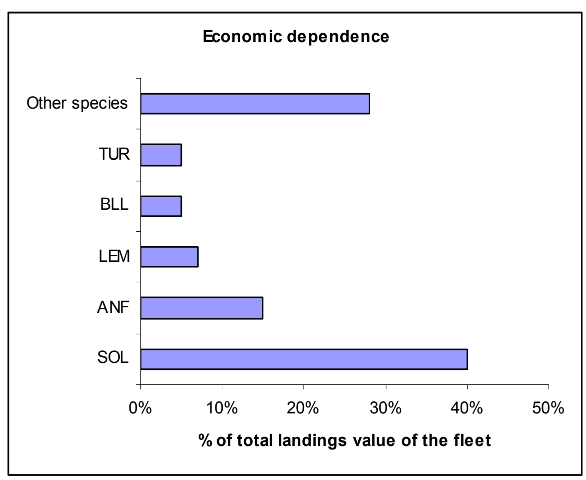
* Part of the total ICES catches for the stock caught by the fleet

Table 7. Economic dependency of the fleet on the main stocks

	Value of landings in Celtic sea M€	Economic dependence to the species in Celtic sea (related to tot value of landings in Celtic sea= 10.9 ME)	Total Economic dependence to the species caught in Celtic sea (related to tot value of landings = 54.6 ME)
Solea solea	4.37	39%	8%
Lophiidae	1.65	15%	3%
Microstomus kitt	0.77	6.9%	1%
Scophthalmus rhombus	0.55	5%	1%
Psetta maxima	0.53	4.8%	1%
Other species	3.05		
Total	10.90		

Total gross revenue of the fleet realized in Celtic sea in 2008 is 10,9 million euros. Total gross revenue of the fleet is 54,6 million euros.





Figures 7 and 8. BELTBB2440 contribution to the fishing mortality of the main target spp and fleets economic dependency on the stocks.

Table 8. Dependence of the fleet total income on the Celtic sea

Total income from landings for Belgian beam trawl 24-40m fleet (M€)	54.60
Dependence of the fleet on the ecosystem (Celtic Sea)	20%

20% of the incomes from landings of the Belgian beam trawl 24-40m fleet come from landings from the Celtic sea. The analysis of the 2008 DCF data available for the **Belgian beam trawl 24-40m fleet** in area 27 can not be used to describe economic performance for the Belgian beam trawl 24-40m fleet in the Celtic Sea (no possibility to disaggregate data).

Total catch of the Belgian Beam Trawl 24-40m in the Celtic Sea: 2 799.76 tonnes

ICES Area: Celtic Sea (VIIe-k)
Country: GBR
Gear: DTS
Length: VL2440

Species with higher contribution to total revenues (TRf) of the fleet segment (80.74% of TRfs in the Celtic Sea): LEZ (*Lepidorhombus* spp or Megrim spp, 29.89% of TRfs), ANF (*Lophidae* spp or Anglerfishes nei, 29.58% of TRfs), NEP (*Nephrops norvegicus* or Norway lobster, 10.36% of TRfs), HKE (*Merluccius merluccius* or European hake, 6.5% of TRfs) and JOD (*Zeus faber* or John Dory, 4.4% of TRfs). Data obtained from the economic dataset from DCF in the STECF Rennes September 2010.

The fleet´s segments contribution to the total landings in the ICES area was estimated using ICES assessment 2010 (2008 catch data for ANF, LEZ, NEP, see comments). Landings were used and not Catch so discards and IUU not accounted for.

Table 9. GBRDTS2440 main target species landings in the Celtic Sea.

Species	STECF landings (tonnes)	Landings_Celtic_ICES_2008 (tonnes)	%Segment/landings	Comments
Lepidorhombus spp	1207.46	12724.00	9.5	*ICES data only reported for VIIb-k and VIIIa,b,d http://www.ices.dk/committe/acom/comwork/report/2010/2010/mgw-78.pdf
Lophidae spp	1024.79	27153.00	3.77	*ICES data only reported for VIIb-k http://www.ices.dk/committe/acom/comwork/report/2010/2010/ang-78ab.pdf
Neprhops	199.82	20400.00	0.98	*ICES data only reported for VII http://www.ices.dk/committe/acom/comwork/report/2010/2010/Nep-VII.pdf
European Hake	407.29	47800.00	0.08	Data provided by STEFC

Table 10. Estimation of partial fishing mortality generated by the fleet segment: $F_{part}=(Lf/L_{ICES})* F_{bar}$
*Note that partial F is estimated using ICES Catch when possible and not landings

Stock	**F_{bar} (stock)**	Lf(2004) (Considering all ICES area VII) (tonnes)	$L_{ICES\ (2004)}$ (tonnes)	F_{part}
Lepidorhombus spp	Data for 2004: 0.3784	610.28	18811.00	0.0123
Lophidae spp	Data for 2004: 0.2595	816.90	27313.00	0.0078
Neprhops	No assessment			
European Hake	Data for 2008	407.29	47800.00	0.0021

Table 11. Economic dependency of the fleet segment on the species and the ecosystem and contribution of the fleet segment to the species F in the ecosystem

SpeciesName	Catch(tonnes)	%catch	Value(M€)	%value
Lepidorhombus spp	1207.46	2.05	3.46	3.30
Lophidae spp	1024.80	1.74	3.43	3.26
Neprhops	199.82	0.34	1.20	1.14
European Hake	407.29	0.69	0.75	0.72
ZeusFaber	106.61	0.18	0.51	0.48

Total main spp in the CS	2945.98	5.00	9.35	8.90
Total CS	3999.15	6.79	11.58	11.03
Total	58862.83	100	105.00	100

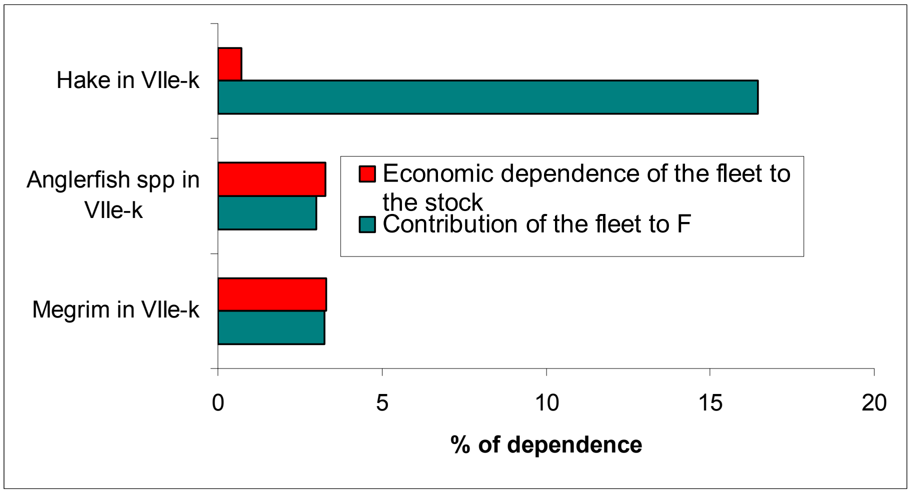


Figure 9. GBRDTS2440 economic dependency on its main target spp.

Economic dependency on the ecosystem : This fleet segment obtains 11.02% of its total annual revenues from the Celtic Sea VIIe-k.

Table 12. Descritptors of fleet profitability (from the AER 2010)

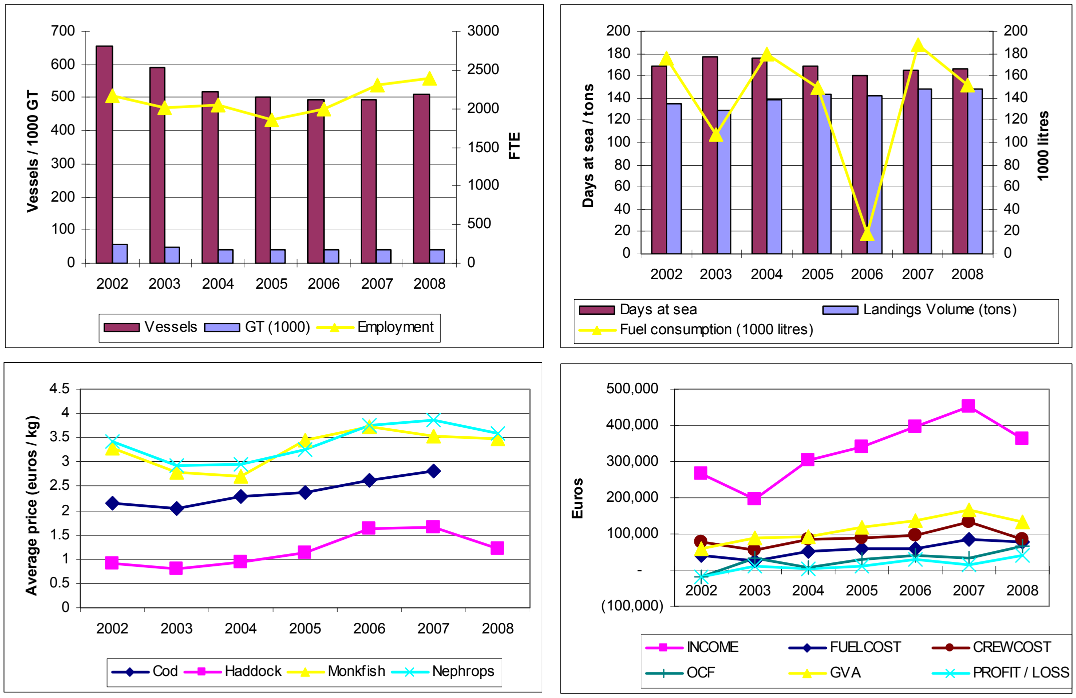
	Number of vessels	FTE (Or total employed)	Days at Sea (1000 days)	Volume of landings (1000 tons)	Value of landings (million euros)	Direct subsidies (million euros)	Total Income (million euros)	Average wage per FTE (euros)	GVA (million euros)	Operating cash flow (million euros)	Profit / loss (million euros)	Capital Value (million euros)	ROI (%)	Investments (million euros)
DTS VL2440	109	715	22.3	58.9	105	6.0	121	37,5	37.9	17.1	10.2	155	0.1	7.4

Fleet description:
This fleet is considered of special interest in the AER 2010. The demersal trawl seine 12-24m fleet segment consisted of 508 active vessels accounting for a total of 41,877 GT in 2008, as shown in Figure 3.20.10. The number of vessels has increased very slightly between 2007 and 2008. Between 2002 and 2008, average annual fishing effort (days at sea) has remained stable at around 165 to 170 days per vessel. Total employment in the segment was 2,394 FTEs in 2008, up slightly on the previous year.

In 2008, vessels in this fleet segment landed an average of 149 tons of seafood and generated an average income of around €364,419 per vessel, a decrease of around 19% compared to 2007. However, vessels generated average profits of €39,028 in 2008, an increase from €13,213 in 2007.

These vessels fish around the entire UK waters for a mix of whitefish demersal species and nephrops. Prices for key species (cod, haddock, monkfish, nephrops) have been quite stable in recent years but fell slightly in 2008 compared with 2007. There is not a good degree of homogeneity of activity, vessel type or financial performance within this DCF segment because of the broad spread of the definition. The species composition and seasonal emphasis of different species varies considerably between the larger vessels and the smaller vessels within this segment. The smaller vessels will mostly stay inshore while the larger ones will fish all over the North Sea and further offshore in general.

Figure 10. UK demersal trawl and seine 12-24m performance trends 2002-2008.



ICES Area: Celtic Sea (VIIe-k)
Country: GBR
Gear: FPO
Length: 00-10

The British pots and traps of 0-10m fleet segment (FPO VL0010) covers a large area surrounding the island of Great Britain, including not only the Celtic Sea but also the Irish Sea, West of Scotland and the North Sea. These areas correspond to ICES divisions 4.a,b,c; 6.a, and 7.a,d,e,f,g,k. It is the segment with the largest number of vessels in the UK (a total of 1926) and employing 1184 FTE.

Table 13. The economic parameters for this fleet are the following:

Fleet segment	Number of vessels	FTE (Or total employed)	Days at Sea (1000 days)	Volume of landings (1000 tons)	Value of landings (million euros)	Direct subsidies (million euros)	Total Income (million euros)	Average wage per FTE (euros)	GVA (million euros)	Operating cash flow (million euros)	Profit / loss (million euros)	Capital Value (million euros)	ROI (%)	Investments (million euros)
FPO L0010	1926	1183.9	277.4	21.4	62.7	1.6	70.6	15,289	46.7	30.2	8.9	111.6	0.1	0.6

Given the limited size of the vessels and large the extension of the area they cover, for operational reasons groups of vessels restrict their activity to only part of the area and belong to many different ports. Therefore this fleet segment may include very different groups of vessels from an economic point of view given their different cost structures and markets. To this respect there is no qualitative information available on the AER as the segment is not considered a segment of special interest. However, this idea is confirmed by the fact that "there was a significant variation between the quartiles, with total operating costs for the most profitable quartile equating to 51% of income compared to 71% in the least profitable quartile" (2008 Economic Survey of the UK Fishing Fleets, Seafish, 2010, p.90). According to the expert knowledge available at the subgroup meeting, there would be at least one group of vessels on the south west coast and another one on the north east, aiming at different market segments.

The definition of the fleet segment has changed from DCR to DCF. Formerly in the DCR there was only one length class of 0-12m. Comparing the most recent 0-10m and 10-12m segments there are differences in catch composition among others that hinder that comparability between both segments. Nevertheless, all data referring to the current 0-10m fleet segment is specified by ICES division, and therefore there has been no problem with data having lower spatial definition (data referring only to ICES area level).

The fleet segment yielded a revenue of 67.214 Mill.Euro in 2008 out of its landings from the Celtic Sea. The most relevant species regarding the value of their landings were European lobster (LBE, 35.25%) , edible crab (CRE,30.82%), whelk (WHE, 19.27%), spinous spider crab (SCR,6.55%), and European seabass (BSS 1,94%). * This harvest is obtained within the 7e-k area, with catches on division 7k (at a much higher distance to the coast) being almost negligeable and with no catches on divisions 7h or 7j. The largest harvests by looking at weight correspond to whelk, edible crab, spinous spider crab, European lobster and cuttlefish which represent a total of 96% of the catches in weight for the segment and the area.

The economic dependence of this fleet segment on the Celtic Sea ecosystem is of 16.72%, meaning the total value of landings of the fleet that comes from the Celtic Sea. The segments also depends on the North Sea in 44.32% and other areas (Irish Sea and West of Scotland, ICES 7a and 6a) in 38.95% which shows the spatial heterogeneity of the fleet segment.

Table 14. Main species for the British pots and traps 0-10, fleet in landing values

SPECIES	**VALUES (M€)**	**Catch (tonnes)**	**% value (related to tot value of landings in Celtic sea= 10.9 ME)**
European lobster	3963304	249.67	**n.a.**

Edible crab	3465510	1970.25	**n.a.**
Whelk	2166749	2826.13	**n.a.**
Spinous spider crab	736041	500.36	**n.a.**
European seabass	217975	30.20	**n.a.**

Despite the availability of data on landings weight and value for this fleet segment at division level, its contribution to the landings of the stocks of the five selected species cannot be calculated because none of the main species by value had an ICES stock assessment. As there was no information on the total landings for these stocks, the mean Fs the proportion of landings and the partial F cannot be calculated.

Table 15. Economic dependence of the fleet on the main stocks

	Value of landings in Celtic sea M	**Economic dependence to the species in Celtic sea (related to tot value of landings in Celtic sea= 11.2 ME)**	**Total Economic dependence to the species caught in Celtic sea (related to tot value of landings = 67.2ME)**
European lobster	**3.96**	**35,25%**	**5,89%**
Edible crab	**3.47**	**30,82%**	**5,15%**
Whelk (gastropode)	**2.17**	**19,27%**	**3,22%**
Spinus spider crab	**0.74**	**6,55%**	**1,09%**
European seabass	**0.22**	**1,94%**	**0,32%**
Other species	**0.69**	**6,18%**	**1,03%**
Total	**11.24**		

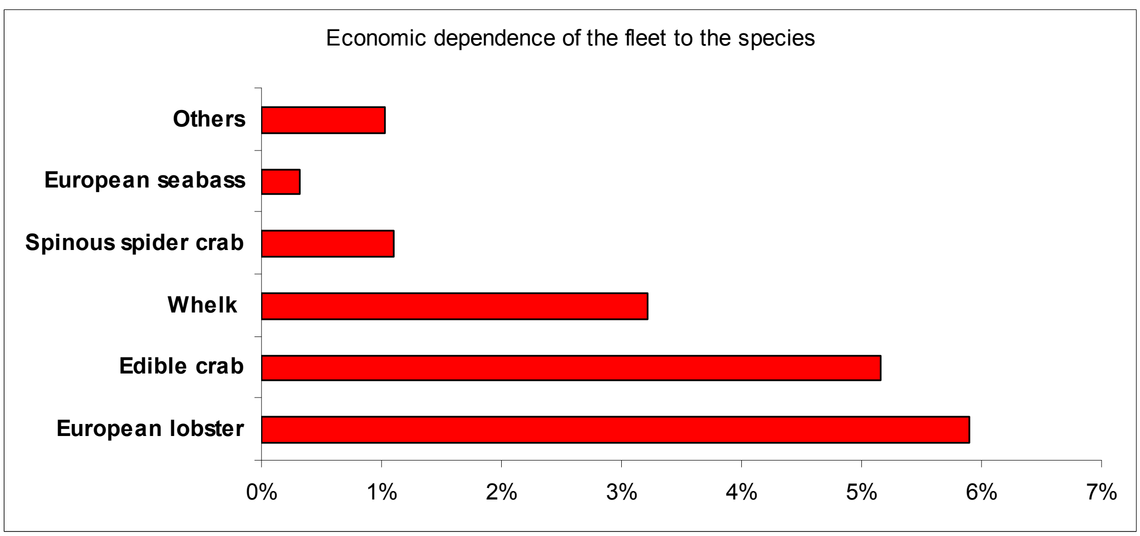


Figure 11. Economic dependence of the fleet on the main stocks

As only 16.72% of the incomes from landings of the British pots and traps 0-10m fleet comes from landings from the Celtic sea the analysis of the 2008 DCF data available for the British pots and traps 0-10m fleet in the supra region can not be used to describe economic performance for the British pots and traps 0-10m fleet in the Celtic Sea (no possibility to disaggregate data according to the selected methodology).

However, the segmet has some intereting characteristics for ecosystem management. The pots and traps <10 segment is able to obtain much higher average prizes thatn other UK fleets, specially of lobster and nephrops (see 2008 Economic Survey of the UK Fishing Fleets, Seafish, 2010, p.89).At the same time, it can be considered a low environmental impact segment (at least for the sea bottom),and, as said before, a segment of high profitability and possibly differentiated economic characteristics depending on the ecosystem.

ICES Area: Celtic Sea (VIIe-k)
Country: GBR
Gear: TBB
Length: 24-40

The economic dependency of this segment, beam trawl (TBB), on the Celtic Sea was 83% in 2008. Some more economic data for this segment was found in the AER reports, shown in the following tables.

Table 16. GBRTBB2440 economic parameters in the AER 2010.

	Number of vessels	FTE (Or total employed)	Days at Sea (1000 d	Volume of landings (1000 tons)	Value of landings (million euros)	Direct subsidies (million euros)	Total Income (million euros)	Average wage per FTE (euros)	GVA (million euros)	Operating cash flow (million euros)	Profit / loss (million euros)	Capital Value (million euros)	ROI (%)	Investments (million euros)
GB TBB VL2440 2008	39.0	131.8	7.1	8.3	19.8	1.1	21.6	40,22	8.6	4.4	2.9	38.1	0.1	0.0
Source: AER, 2010														

The Great Britain TBB VL24-40 was earning a total of 20 Mill Euro in 2008 from the harvest in the Celtic Sea, of which the main species were ANF Sole CTL, LEZ and LEM. This harvest is made within the so-called 27.7e-k area. These species constituted a total of 74% of total values of landings this year. The share of total landings of these species have been estimated (see table 14).

Table 17. GBRTBB2440 catch and value from the main target spp in the Celtic Sea.

Celtic Sea GB TBB 24-40, 2008

SPECIES*	M€	tonnes	Total landings (tonens)	Share
Anglerfishes	4.90	1363.40	32200	4%
Sole	4.07	348.98	1645	21%
Cuttlefish	3.18	1689.96	NA	
Megrim	1.64	365.25	11300	3%
Lemon sole	0.91	164.12	NA	

**ANF is Anglerfishes,*
SOL is sole,
CTL is Cuttlefish, CEPHALOPODA1
LEZ is megrim
SCE is Pecten maximus, Great Atlantic scallop, BIVALVIA

ICES reports on total landings of the Anglerfish and Megrim in the Celtic sea and West of Scotland together, and it is not possible to find a share of this segment on landings taking place only in the Celtic Sea. We have thus applied the ICES total landings for the two areas in the table (32 200 tons for Anglerfish and 11300 tons for Megrim). For sole, the ICES reports on the Celtic Sea VII f and g, VII e and VII h-k in different reports which have been aggregated to find the total landing (0.225+0.67+0.75 = 1 645 tons).

To have an idea of total impact on the ecosystem of the respective fleet, we have estimated the shares that respective catch specified in Celtic Sea has on total harvest of this the fleet in all areas.

Table 18. Shares of catch and value of the species in the area for Celtic Sea GB TBB 24-40, 2008

SPECIES	M€		tonnes	
Anglerfishes	4.90	20%	1363.40	16%
Sole	4.07	17%	348.99	4%
Cuttlefish	3.18	13%	1689.96	20%
Megrim	1.64	7%	365.25	4%
Lemon sole	0.91	4%	164.13	2%
Other	5.11	21%	2543.49	31%

Celtic Sea (CS)	19.81	83%	6475.21	78%
TOT	24.00	100%	8291.39	100%

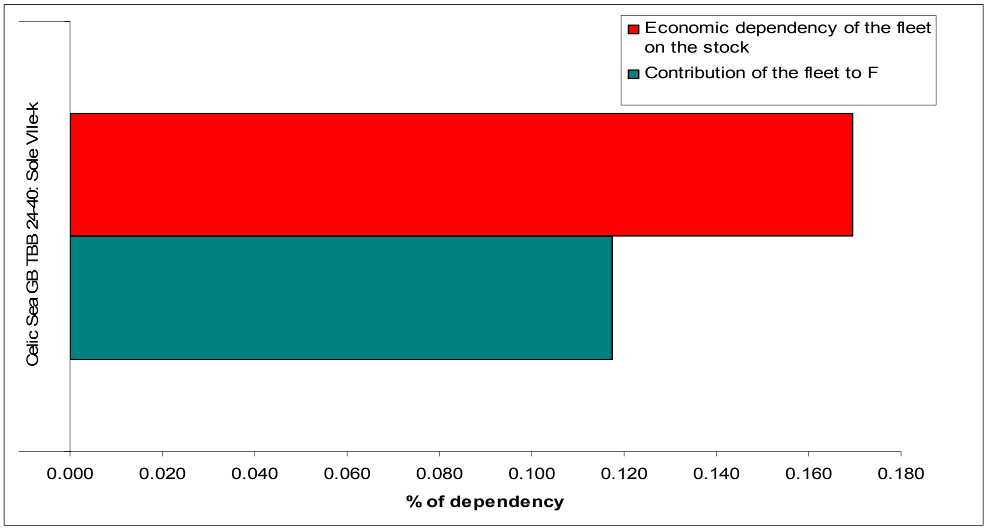


Figure 12. Economic dependency on main stocks and contribution to their fishing mortality.

ICES Area: Celtic Sea (VIIe-k)
Country: IRL
Gear: DTS
Length: 12-24

Irish Demersal trawlers and/or demersal seiners 12-18m or 12-24 m

The Irish DTS fleet 12-24m is made of single demersal trawlers and twin trawlers. Two main strategies are identified regarding the species targeted: Nephrops trawlers and whiting trawlers. Strategies also depend on the vessel size smaller vessels operate in coastal area during day trip whereas larger vessels have longer trip and farer fishing grounds. The new DCF segmentation divided this fleet into two length segments Irish DTS fleet 12-18m and Irish DTS fleet 18-24m which better reflect heterogeneity in strategies and as a consequence in revenue and cost structure. However the old segmentation were used for the description according to data availability and the detail was provided by sub-fleet (12-18m and 18-24m) when it was possible.

The main fishing area of the irish DTS fleet 12-24 m, as described in the AER, are: irish sea, celtic sea, west coast and porcupine banks. Total gross revenue of the fleet realized in Celtic sea in 2008 is 33.5 million euros. Total gross revenue of the fleet is 45.6 million euros. **73% of the total value of landings of the fleet comes from the celtic sea**. In this case, economic data of the whole fleet can be used as a proxy to describe the economic performance of the fleet operating in Celtic sea.

In 2007, the main species landed in value by the Irish DTS fleet 12-24 m are: Nephrops (45.7%), Monk (14.9%), Whiting (7%), Megrim (4.9%) and Haddock (4.4%) (Anderson and Guillen (Ed), 2009). In 2008, the main species landed in value (part of the gross revenue of the fleet formed by the species) in Celtic sea were Nephrops (37%), monkfish (36%), Megrim (6%) Haddock (4%) whiting (2%) and cod (2%).

Contribution of the irish Demersal trawler fleet 12-24 m in Celtic Sea to fishing mortality of the following stocks was thus evaluated through a ratio of the landings of the fleet in weight for the species compared to total landings registered in 2008 for the stock according to 2010 ICES report on stock assessment.

Table 19. IRLDTS1224 main species considered.

Stock concerned	Reference
Nephrops in VII	ICES advice 2010 for *Nephrops* in Subarea VII http://www.ices.dk/committe/acom/comwork/report/2010/2010/Nep-VII.pdf
Megrim in VIIb,c,e-k, VIIIabd	ICES advice 2010 for Megrim (*Lepidorhombus whiffiagonis*) in Divisions VIIb k and VIIIa,b,d http://www.ices.dk/committe/acom/comwork/report/2010/2010/mgw-78.pdf
Haddock in VII b-k	ICES advice 2010 for Haddock in Divisions VIIb k http://www.ices.dk/committe/acom/comwork/report/2010/2010/had-7b-k.pdf
Whiting in VIIe-k	ICES advice 2010 for Whiting in Divisions VIIe k http://www.ices.dk/committe/acom/comwork/report/2010/2010/whg-7e-k.pdf
Cod VII e-k	ICES advice 2010 for Cod in Divisions VIIe k (Celtic sea cod) http://www.ices.dk/committe/acom/comwork/report/2010/2010/cod-7e-k.pdf

Table 20. Catch and value from the main target spp in the Celtic Sea.

	Irish DTS 12-24 m Volume of landings t	Agreed TAC t	Contribution to fishing mortality (ref TAC)*	ICES catches (landings + discards or estimated highgrading)	Contribution to fishing mortality (ref ICES Catches)**
Nephrops in VII	3083	25153	12%	20400	**15%**
Megrim in VIIb,c,e-k, VIIIabd	617	20400	3%	7000	**9%**
Haddock in VII b-k	675	11579	6%	12700	**5%**
Whiting in VIIe-k	565	19900	3%	6100	**9%**
Cod in VII e-k	275	4300	6%	4000	**7%**
Other species	2494				
Total	7709				

*Part of the total landings for the stock (agreed TAC) caught by the fleet
** Part of the total ICES catches for the stock caught by the fleet

Table 21. Catch and value from the main target spp in the Celtic Sea at subfleet level.

Detail	DTS 12-18 m		DTS 18-24 m	
	Volume of landings t	Contribution to fishing mortality	Volume of landings t	Contribution to fishing mortality
Nephrops in VII	338	2%	2745	13%
Megrim in VIIb,c,e-k, VIIIabd	178	3%	440	6%
Haddock in VII b-k	172	1%	503	4%
Whiting in VIIe-k	64	1%	565	9%
Cod in VII e-k	29	1%	275	7%
Other species	498			
Total	1278			

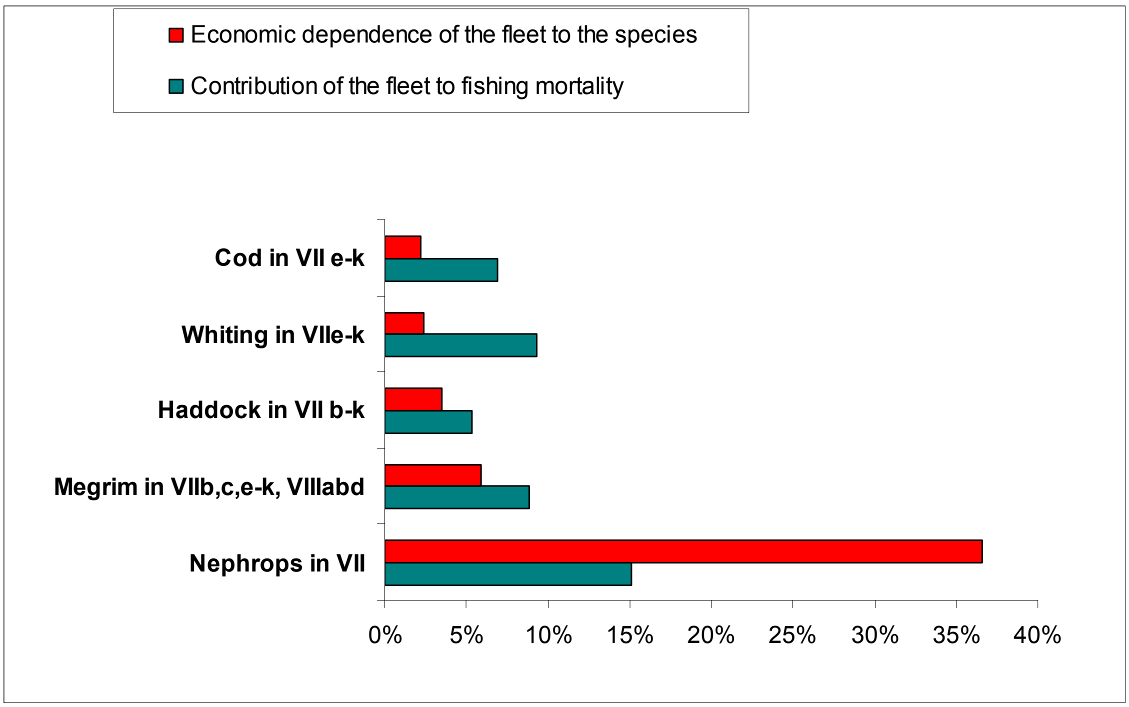
Table 22. Economic dependency on the fleet on main stocks and ecosystem.

	Value of landings in Celtic sea M€	Economic dependence to the species in Celtic sea (related to tot value of landings in Celtic sea= 33.5 ME)	Total Economic dependence to the species caught in Celtic sea (related to tot value of landings = 45.6 ME)
Nephrops in VII	12.26	37%	27%
Haddock in VII b-k	1.97	6%	4%
Megrim in VIIb,c,e-k, VIIIabd	1.17	4%	3%
Whiting in VIIe-k	0.80	2%	2%
Cod in VII e-k	0.73	2%	2%
Other species	16.57	49%	
Total	33.49		

Table 23. Economic dependency on the fleet on main stocks and ecosystem at subfleet level..

Detail	DTS 12-18 m		DTS 18-24 m	
	Value of landings N€	Economic dependence	Value of landings M€	Economic dependence
Nephrops in VII	1.61	38%	10.65	36%
Megrim in VIIb,c,e-k, VIIIabd	0.54	13%	1.43	5%
Haddock in VII b-k	0.30	7%	0.87	3%
Whiting in VIIe-k	0.07	2%	0.72	2%
Cod in VII e-k	0.08	2%	0.66	2%
Other species	1.65	39%	14.91	51%
Total	4.25		29.24	

Figure 13. Economic dependency on main stocks and contribution to their fishing mortality.



Economic performance of the fleet

The analysis of the 2008 DCF data available for the irish DTS fleet 12-24 m in area 27 provides the following results:

Nb of vessels	124
average GT	97
average kW	294
average Age	27
average Lenght	17

Effort: 37242 trips

2008 data on profit, gross value added or other economic performances are not available.

Economic data for Ireland are not available in the AER 2010.

AER 2009 (Anderson and Guillen (Ed), 2009) provides however data on the irish demersal trawler and seiner fleet 12-24 m on the 2003-2007 period. No distinction is made between the fishing area where the fleet operate. However, as the part of the landing value coming from Celtic Sea is over 70%, we can assume that the fleet spent most of its time in the celtic sea and that economic performances described for the whole fleet is an acceptable proxy for analyzing the economic profitability of this fleet in Celtic sea.

The irish DTS fleet 12-24 m consisted of 148 vessels in 2007 with an average gross revenue of 457 meuros per vessel (58.8 million Euros for the whole fleet). This fleet represented around 719 FTE in 2007. The following tables out of the 2009 AER (Anderson and Guillen (Ed), 2009) provide the available data on the Irish DTS 12-24 m characteristics in terms of landings in volume and value, FTE, or KW and economic performances.

Table 24. Landings, value and fishing effort at different units for the fleet from the AER 2010.

FISHING TECHNIQUE	VESSEL LENGTH	VOLUME OF LANDINGS (1000t)	VALUE OF LANDINGS (mEUR)	NUMBER OF VESSELS	TOTAL KW	EMPLOYMENT (FTE)	GVA (mEUR)
Drift and fixed nets	12-24m	1.6	3.4	19.0	3.8	59.0	
Drift and fixed nets	24-40m	0.2	0.4	1.0	0.5	6.0	
Dredges	12-24m	0.8	4.3	23.0	4.4	80.0	
Dredges	24-40m	0.1	0.4	28.0	10.4	132.0	
Dredges	Over 40m	0.2	0.1	7.0	5.0	48.0	
Demersal trawl and seine	12-24m	23.6	58.8	148.0	40.8	719.0	29.8
Demersal trawl and seine	24-40m	12.6	26.2	44.0	25.4	326.0	13.3
Demersal trawl and seine	Over 40m	0.6	1.4	3.0	3.8	26.0	
Pots and traps	12-24m	4.0	6.0	29.0	4.6	109.0	2.3
Pots and traps	24-40m	0.6	1.1	2.0	1.0	10.0	
Gears using hooks	12-24m						
Gears using hooks	24-40m	0.4	0.9	1.0	0.7	7.0	
Polyvalent passive gears	12-24m						
Combining mobile and passive gears	0-12m	15.7	38.0		45.8		36.0
Combining mobile and passive gears	12-24m	0.4	1.1	1.0	0.2	4.0	
Pelagic trawl and seine	12-24m	2.3	1.7	4.0	1.4	14.0	
Pelagic trawl and seine	24-40m	27.6	13.5	8.0	6.0	96.0	
Pelagic trawl and seine	Over 40m	125.1	55.0	18.0	42.3	263.0	
Beam trawl	12-24m	0.8	3.1	7.0	1.8	33.0	
Beam trawl	24-40m	2.0	6.9	12.0	9.4	71.0	2.5
Beam trawl	Over 40m	1.6	3.4	19.0	3.8	59.0	

Table 25. Irish fleets productivity change between 2006-7. Source: AER 2009

FISHING TECHNIQUE	VESSEL LENGTH	INCOME / VESSEL (%)	YEARLY CATCH / VESSEL (%)	INCOME / DAYS AT SEA (%)	GVA / DAYS AT SEA (%)	GVA / FTE (%)	CREW SHARE / FTE (%)
Drift and fixed nets	12-24m		5.5				
Drift and fixed nets	24-40m		-33.2				
Dredges	12-24m		21.1				
Dredges	24-40m		-42				
Dredges	Over 40m		69.6				
Demersal trawl and seine	12-24m	14.5	4.8	-1.2	11.5	21	12
Demersal trawl and seine	24-40m	-3.3	2.6	1.8	10.7	18.4	0.9
Demersal trawl and seine	Over 40m		52.3				
Pots and traps	12-24m		28.7				
Pots and traps	24-40m		-56				
Gears using hooks	12-24m						
Gears using hooks	24-40m		38.8				
Polyvalent passive gears	12-24m						
Combining mobile and passive gears	0-12m	7.2	-48.5	1	-38.7	-31.9	-16.4
Combining mobile and passive gears	12-24m						
Pelagic trawl and seine	12-24m						
Pelagic trawl and seine	24-40m		46.9				
Pelagic trawl and seine	Over 40m		2.6				
Beam trawl	12-24m		159.2				
Beam trawl	24-40m	-14.4	-7.5	-7	8.5	-1.6	-7.4
Beam trawl	Over 40m						

Table 26. Irish fleets economic parameters. Source: AER 2009

	2002	2003	2004	2005	2006	2007
Costs and earnings (average per vessel)						
INCOME (1000 EUR)			433.6	397.6	399.1	457
CASH-FLOW (1000 EUR)			24.2	27.5	39.8	62.7
PROFIT (1000 EUR)			-16.1	-10.5	11.4	36.9
GVA (1000 EUR)			184.1	154	155.8	201.4
Other economic indicators (average per vessel)						
EMPLOYMENT (TOTAL)		4.6	4.6	4.6	4.5	4.9
INVESTMENT (1000 EUR)		396.1	613.2	478.5	302.6	332.6
EFFORT DAYS		129.4	144.7	157.3	142.8	165.5
Capacity indicators (total for fleet segment)						
LANDINGS WEIGHT (1000t)		25.5	24.7	26.3	24.5	23.6
FLEET (number)		215	197	167	161	148
Fleet GT (1000)		18.1	17.9	15.9	15.3	13.6
Fleet kW (1000)		54.4	52.3	45.9	44.9	40.8

ICES Area: Celtic Sea (VIIe-k)
Country: IRL
Gear: DTS
Length: 24-40

The Demersal trawler 24-40 m fleet segment consists of 31 single and twin trawlers targeting mainly Nephrops and whitefish species. As described in the AER, the vessels of this fleet operate on the same fishing grounds as the Demersal trawler 12-24 m fleet but larger vessel fish also on the Rockall grounds and the Porcupine banks.

Total gross revenue of the fleet realized in Celtic sea in 2008 is 12.6 million euros. Total gross revenue of the fleet is 22.1 million euros. **57% of the total value of landings of the fleet comes from the celtic sea**. In this case, economic data of the whole fleet can not be used as a proxy to describe the economic performance of the fleet operating in Celtic sea.

In 2008, the main species landed in value were nephrops (39%), monkfish (25%), Haddock (10%), megrim (6%), hake (4%) and whiting (4%).

Contribution of the irish Demersal trawler fleet 24-40 m in Celtic Sea to fishing mortality of the following stocks was evaluated through a ratio of the landings of the fleet in weight for the species compared to total landings registered in 2008 for the stock according to 2010 ICES report on stock assessment.

Table 27. Catch and value from the main target spp in the Celtic Sea.

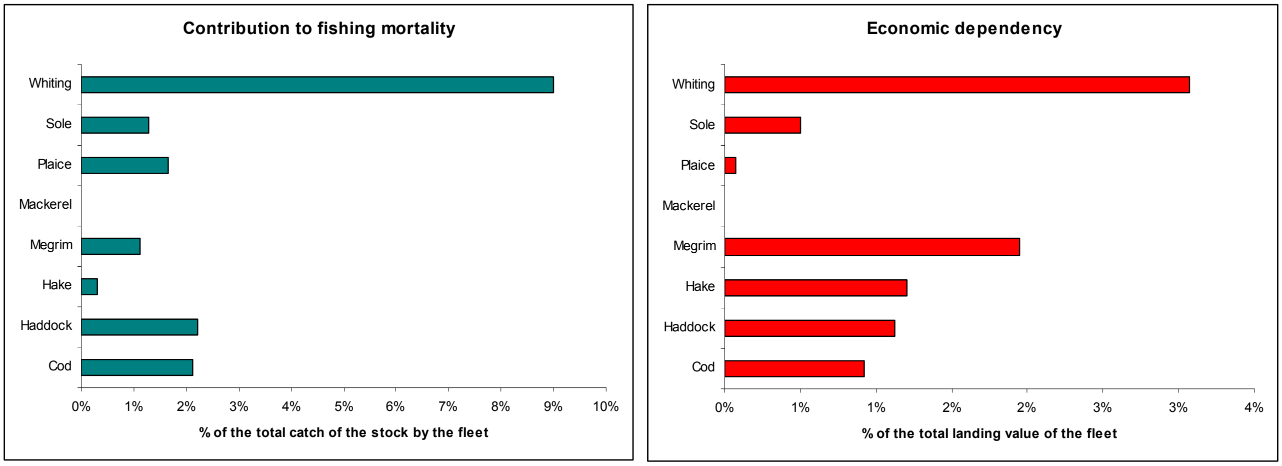
	Irish DTS 24-40 m Volume of landings t	ICES catches t (landings + discards)	Contribution to fishing mortality (ref ICES Catches)
Cod	77	3639	**2%**
Haddock	155	7013	**2%**
Hake	144	47800	**0%**
Megrim	142	12724	**1%**
Mackerel	3	611063	**0%**
Plaice	7	438	**2%**
Sole	10	800	**1%**
Whiting	512	5700	**9%**

Table 28. Economic dependency of the fleet to stock assessed in Celtic sea is 9%.

	Irish DTS 24-40 m Value of landings M euros	Economic dependence to the species in Celtic sea (related to tot value of landings in Celtic sea=12.6 ME)	Total Economic dependence to the species caught in Celtic sea (related to tot value of landings = 22.1ME)
Cod	0.203	2%	1%
Haddock	0.248	2%	1%
Hake	0.267	2%	1%
Megrim	0.431	3%	2%
Mackerel	0.001	0%	0%
Plaice	0.016	0%	0%
Sole	0.111	1%	1%
Whiting	0.679	5%	3%
Dependency on stock			**9%**

According to the economic dependency of the fleet to the Celtic sea (57%), it is a strong assumption to assume that economic indicators for the whole fleet can be used as a proxy for the economic performances of the fleet in the Celtic Sea.

Figure 14. Economic dependency on main stocks and contribution to their fishing mortality.



ICES Area: Celtic Sea (VIIe-k)
Country: IRL
Gear: TBB
Length: 24-40

The economic dependency of this segment, beam trawl, on the Celtic Sea is 88% of total landing value. Some more economic data for this segment was found in the AER reports, shown in the following tables.

Table 29. Catch, value and effort for the fleet in the CS. *Source AER, 2009*

		VOLUME OF LANDINGS (tonnes)	VALUE OF LANDINGS (M€)	NUMBER OF VESSELS	TOTAL KW	EMPLOYMENT (FTE)	GVA (mEUR)*
Beam trawl	24-40m	2000	6.9	12.0	9.4	71.0	2.5

Table 30. Changes in economic parameters between 2006 and 2007. *Source AER, 2009*

%	Income per vessel	Yearly catch per vessel	Income per days at sea	GVA per days at sea	GVA per FTE	Crew share per FTE
IRL TBB VL2440 2006-2007	-14.4	-7.5	17	8.5	-1.6	-7.4

Total landing in 2007 was 5.3 Mill Euro from landings stemming from the Celtic Sea. The five species LEZ, MNX, HAD, COD and LEM consisted of a total of 72% of total catch landing value.

Table 31. Catch and value from the main target spp in the Celtic Sea.

Celtic Sea IRL TBB 24-40, 2008

SPECIES*	M€	tonnes	Total landings (tonnes)	Share
Megrim	1.15	251.31	11300	2%
Macrobrachium nipponense	1.09	268.15	NA	
Haddock	0.21	102.19	6200	2%
Cod	0.18	65.02	3600	2%
Lemon sole	0.16	46.36	NA	

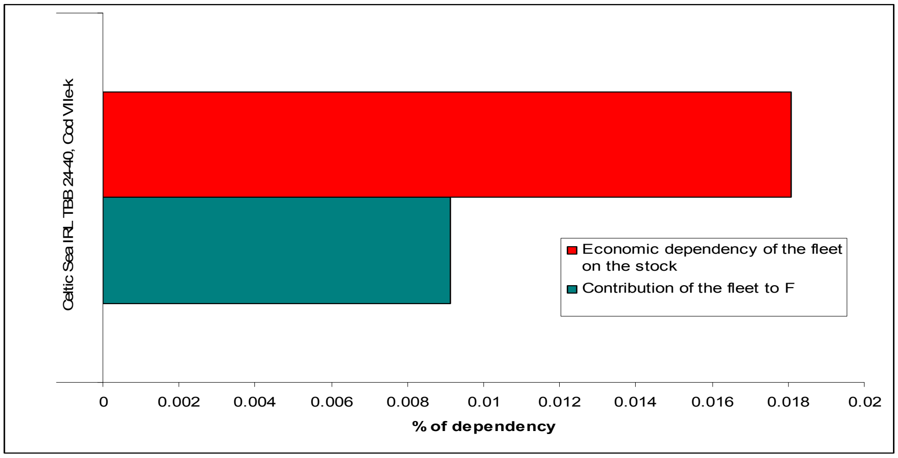
The ICES reports on Haddock in the Celtic Sea and the West of Scotland together. The share is thus from the total landing values in the two areas which is 6200 tons. Cod is reported as ICES landings.

Table 32. Production and value dependency on the stocks.

Celtic Sea IRL TBB 24-40, 2008

SPECIES	M€		tonnes	
Megrim	1.15	26%	251.32	20%
Macrobrachium nipponense	1.09	25%	268.15	21%
Haddock	0.21	5%	102.20	8%
Cod	0.18	4%	65.02	5%
Lemon sole	0.16	4%	46.36	4%
Other	**1.09**	**25%**	**280.47**	**22%**
CS	**3.87**	**88%**	**1013.52**	**81%**
TOT	**4.41**	**100%**	**1249.43**	**100%**

Figure 15. Economic dependency on main stocks and contribution to their fishing mortality.



ICES Area: Celtic Sea (VIIe-k)

Country: IRL
Gear: PMP
Length: 00-12

The economic dependency of this segment called combining mobile and passive gears (PMP) on the Celtic Sea was 33% in 2007. Some more economic data for this segment was found in the AER reports, shown in the following tables.

Table 33. Catch, value and effort for the fleet in the CS. *Source AER, 2009*

		VOLUME OF LANDINGS (tonnes)	VALUE OF LANDINGS (M€)	NUMBER OF VESSELS	TOTAL KW	EMPLOYMENT (FTE)	GVA (mEUR)*
Combining mobile and passive gears	0-12m	15700	38.0	-	45.8	-	36.0

Source AER, 2009

Table 34. Changes in economic parameters between 2006 and 2007. *Source AER, 2009*

%	Income per vessel	Yearly catch per vessel	Income per days at sea	GVA per days at sea	GVA per FTE	Crew share per FTE
Combining mobile and passive gears 0-12m	7.2	-48.5	1	-36.7	-31.9	-16.4

Source AER, 2009

The main species in the PMP fisheries in Ireland are PAL, NEP, COD, SCE and POL, which constitute a total of 87.2.5% of total catch for this segment which was 7.2 millions Euro in 2007.

Table 35. Catch and value from the main target spp in the Celtic Sea.

SPECIES*	M€	tonnes	Total landings (tonnes)	Share
Palaemonidae	4.03	607.71	NA	
Norway lobster	1.13	192.3	NA	
Pollack	0.60	352.86	NA	
Cod	0.26	88.71	4300	2%

We had to use ICES landings as observed landings were not available for Cod in this region. The landings for cod were nicely specified for the exact area that we wanted to study, the Celtic Sea 27.7e-k.

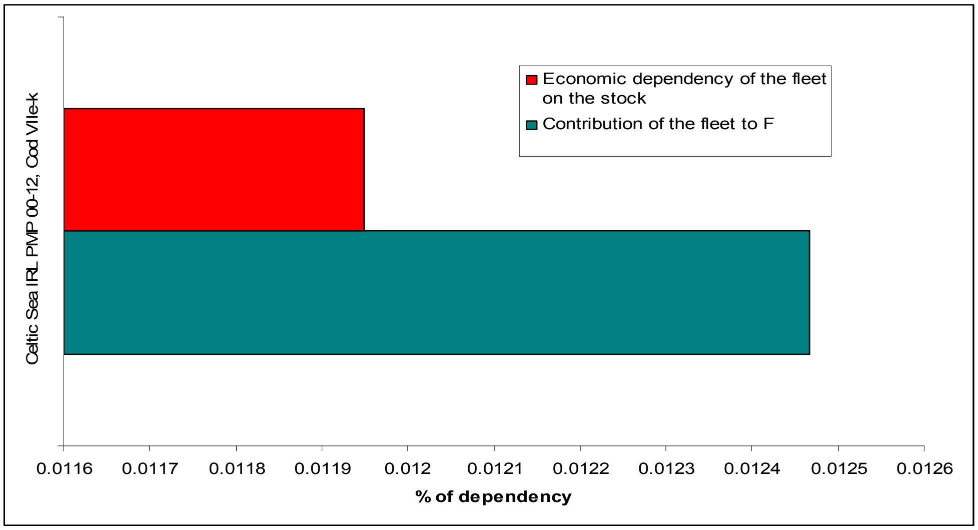
To have an idea of total impact on the ecosystem of the respective fleet, we have estimated the shares that respective catch specified in Celtic Sea has on total harvest of this the fleet in all areas.

Table 36. Production and value dependency on the stocks.

Celtic Sea IRL PMP 00-12 2007

SPECIES	M€		tonnes	
Palaemonidae	4.03	19%	607.708	4%
Norway lobster	1.13	5%	192.265	1%
Pollack	0.60	3%	352.858	2%
Cod	0.26	1%	88.711	1%
Great Atlantic scallop	0.23	1%	112.880	1%
Other	**0.92**	**4%**	**2910.365**	**20%**
CS	**7.16**	**33%**	**4264.787**	**29%**
TOT	**21.48**	**100%**	**14892.378**	**100%**

Figure 16. Economic dependency on main stocks and contribution to their fishing mortality.



ICES Area: Celtic Sea (VIIe-k)
Country: IRL
Gear: PTS
Length: VL40XX

Species with higher contribution to total revenues of the fleet segment (100% of TRfs): MAC (*Scomber scombrus* or Atlantic mackerel, 59.98% of TRfs), BOC (*Capros aper* or Boarfish, 21.4%), BOR (*Caprodidae* or Boarfishes nei, 14.52%), JAX (*Trachurus spp* or Jack and Horse mackerel nei, 2.38%) and HER (*Clupea harengus* or Atlantic herring, 1.71%). Data obtained from the economic dataset from DCF in the STECF Rennes September 2010.

The fleet´s segments contribution to the total landings in 2006 for HER in the ICES area was estimated using ICES assessment 2010. Landings were used and not Catch so discards and IUU not accounted for.

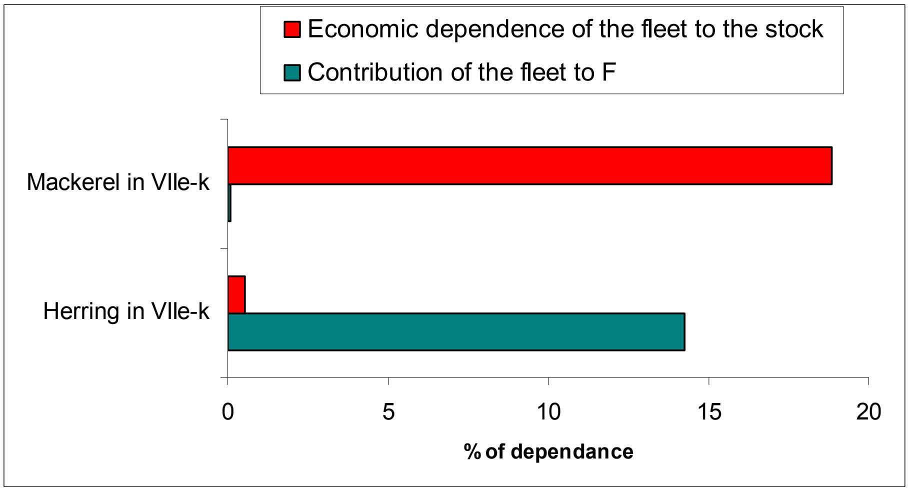
Table 37. Catch from the economically most important target species for the fleet.

Species	STECF landings (tonnes)	Catch_Celtic_ICES_2008 (tonnes)	%Segment/ landings	Comments
Herring	1088.000	8300	13.11%	*2007 Catch and value from STECF database and 2006 ICES catch data only VIIg,h,j,k http://www.ices.dk/committe/acom/comwork/report/2010/2010/her-irls.pdf
Mackerel	494.904	611063	0.08099	

Table 38. Economic dependency of the fleet segment on the species and the ecosystem and contribution of the fleet segment to the species F in the ecosystem

SpeciesName	Catch(tonnes)	%	Value(M€)	%
Capros aper	12483.724	24.76	2.996	6.73
Caproidae	1588	3.14	2.03	4.57
Clupea harengus	1088	2.16	0.24	0.54
Trachurus spp	1401.690	2.78	0.33	0.75
Scomber scombrus	494.904	0.98	8.40	18.85
Total main spp in the CS	**17056.32**	**33..82**	**140.01**	**31.43**
Total CS	**17056.32**	**33..82**	**140.01**	**31.43**
Total	**504182.62**	**100**	**445.48**	**100**

Figure 17. Economic dependency of the fleet segment on the main stocks and the ecosystem and contribution of the fleet segment to the species F in the ecosystem



Economic dependency on the ecosystem

This fleet segment obtains 31.43% of its total annual revenues (Income from 2006, not dissagregated in Income from landings or other sources) from the Celtic Sea VIIe-k.

Table 39. Estimation of partial fishing mortality generated by the fleet segment: F_{part}=(Lf/L_{ICES})*F_{bar}
*Note that partial F is estimated using ICES Catch when possible and not landings

Stock	**Average F_{bar} (stock)**	Lf(tonnes)	L_{ICES} (tonnes)(2007)	F_{part}
Herring	0.225	1088	7636	0.032
Mackerel (Scomber scombrus)	0.237	494.904	611063	0.019

No data on Irish fleets in the AER 2010.

ICES Area: Celtic Sea (VIIe-k)
Country: NDL
Gear: TM
Length: VL40XX

Species with higher contribution to total revenues of the fleet segment (100% of TRfs): JAX (*Trachurus spp* or Jack and Horse mackerel nei, 58.74%), MAC (*Scomber scombrus* or Atlantic mackerel, 18.93% of TRfs), WHB (*Micromesistius potassou* or Blue whiting, 9.73%), CJM (*Trachurus muphiy* or Chilean Jack Mackerel, 9.56%%), and PIL (*Sardina pilchardus* or European pilchard (Sardine), 1.63%). Data obtained from the economic dataset from DCF in the STECF Rennes September 2010.

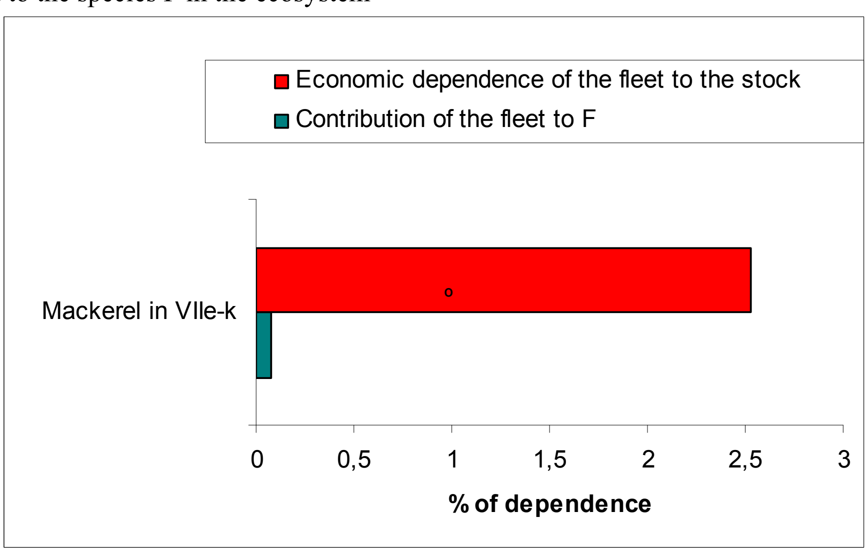
Table 40. The fleet´s segments contribution to the total landings in 2008 for MAC in the ICES area was estimated using ICES assessment 2010. Landings were used and not Catch so discards and IUU not accounted for.

Species	STECF landings (tonnes) fleet	Landings_Celtic _ICES_2008 (tonnes)	%Segment/ landings	Comments
Scomber scombrus	5636.431	611063	0.080	Data provided in the STECF

Table 41. Catch and economic dependency on the stocks.

Species	SpeciesName	Catch (tonnes)	%Catch	Value (M€)	%Value
JAX	Trachurus spp	26759.672	8.3529	11.12	7.85
MAC	Scomber scombrus	5636.431	1.7594	3.58	2.53
WHB	Micromesistius poutassou	5418.770	1.6914	1.84	1.30
CJM	Trachurus murphyi	3472.862	1.0840	1.81	1.28
PIL	Sardina pilchardus	1101.049	0.3437	0.31	0.22
Total CS		**42388.784**	**13.231**	**18.66**	**13.18**
Total areas		**320364.111**	**100**	**141.62**	**100**

Figure 18. Economic dependency of the fleet segment on the main stocks and the ecosystem and contribution of the fleet segment to the species F in the ecosystem



Economic dependency on the ecosystem

The economic data are not complete enough to relate this fleet segments profits in areas VIIe-k to its total in order to estimate its dependency on the ecosystem.

Table 42. Estimation of partial fishing mortality generated by the fleet segment: $F_{part}=(Lf/L_{ICES})*F_{bar}$

Species	**F_{bar} (stock)**	Lf (tonnes)	L_{ICES} (tonnes)	F_{part}
Scomber scombrus	0.237	494.904	611063	0.0002

Descritptors of fleet profitability (from the AER 2010)

Table 43. The Dutch fleet composition and key indicators in 2008.

	Number of vessels	FTE (Or total employed)	Days at Sea (1000 days)	Volume of landings (1000 tons)	Value of landings (million euros)	Direct subsidies (million euros)	Total Income (million euros)	Average wage per FTE (euros)	GVA (million euros)	Operating cash flow (million euros)	Profit / loss (million euros)	Capital Value (million euros)	ROI (%)	Investments (million euros)
NEDTMVL40XX	13	508	3.4	320	142	0.0	142	0	48.7	12.6	-4.7	229.6	0	1

Importance of the fleet

This is the most important segment of the Dutch fleet in terms of volume and value of landings with over 40 metres segment. The total gross value added of this fleet was also the highest (49 million euros). The pelagic fleet is rather small but most of the vessels have a high capacity. The value of landings of the pelagic trawl fleet is also the highest but much closer to the value of landings of the second largest sector: over 40m beam trawlers. Price levels of pelagic (frozen) fish are traditional much lower than those of most demersal (fresh) fish. Employment in this segment was 508 FTE.

ICES Area: Celtic Sea (VIIe-k)
Country: FRA
Gear: DTS
Length: 12-24

The economic dependency of this segment called demersal trawl and seine (DTS) on the Celtic Sea was 60% in 2007. Some more economic data for this segment was found in the AER reports, shown in the following tables.

Table 44. Catch, value and effort for the fleet in the CS. *Source AER, 2009*

		VOLUME OF LANDINGS (tonnes)	VALUE OF LANDINGS (M€)	NUMBER OF VESSELS	TOTAL KW	EMPLOYMENT (FTE)	GVA (mEUR)*
Demersal trawl and seine	12-24m	75860	261.85	484	160.56	2	209

Table 45. Catch, value and effort for the fleet in the CS at subfleet level. *Source AER, 2009*

FLEET SEGMENT	NUMBER OF VESSELS	VALUE OF LANDINGS (million)	DIRECT SUBSIDIES (million)	INCOME (million)	AVERAGE WAGE	GVA (million)	OCF (million)	PROFIT / LOSS (million)	INVESTMENTS (million)
DTS VL1218	196	82.3	1.0	83.3	37,644	35.8	8.5	-0.5	8.3
DTS VL1824	233	153.6	4.7	159.6	37,817	46.6	5.7	-13.5	2.8

Source: AER 2010

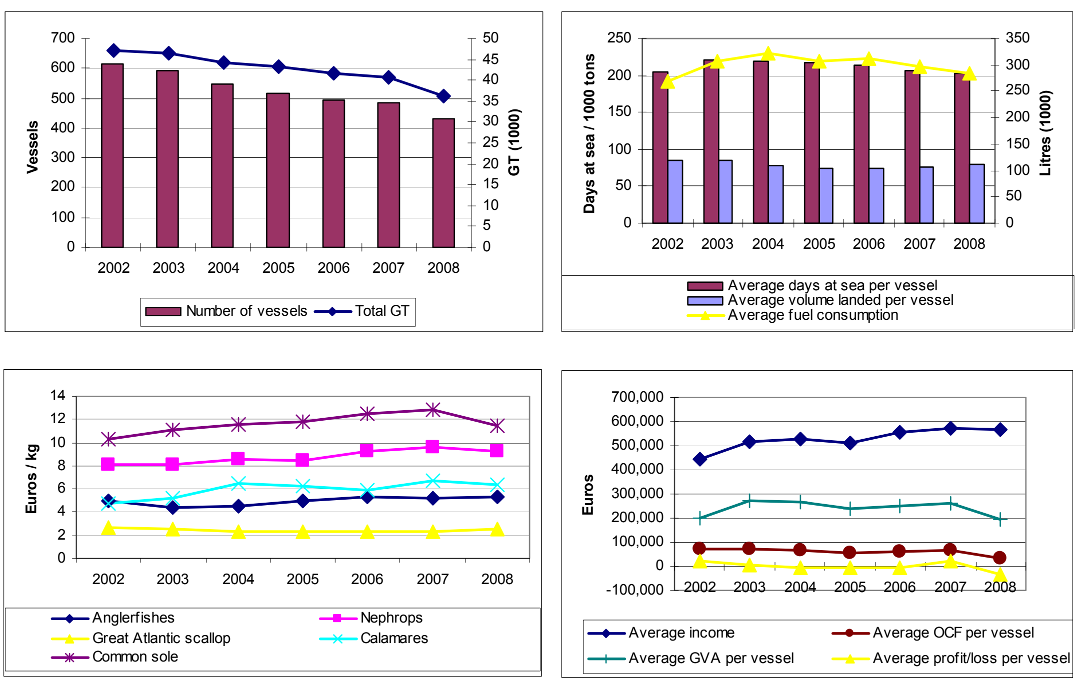


Figure 19. French demersal trawl and seine 12-24m performance trends 2002-2008
French fleets, includes the whole area 27.7. This fleet segment's revenue was a total of in 2007. The species ANF, NEP, SQZ, CTL, COD, MUR, SKA, JOD and WHG, which constitute a total of 67% of total landings.

Table 46. Catch and economic dependency on the main target stocks.

Celtic sea FRA DTS 12-24 2007

SPECIES*	M€	tonnes	Total landings (tonnes)	Share
Anglerfishes	30.50	5846.88	36100	16%
Norway lobster	20.38	2110.39	NA	
Inshore squids	11.79	1790.90	NA	
Cuttlefish	9.72	4673.27	NA	
Cod	7.91	2088.90	4300	49%
Surmullet	7.62	2054.86	NA	
Raja rays	6.70	2841.50	NA	
John dory	6.39	590.74	NA	
Whiting	5.70	3135.24	9100	34%

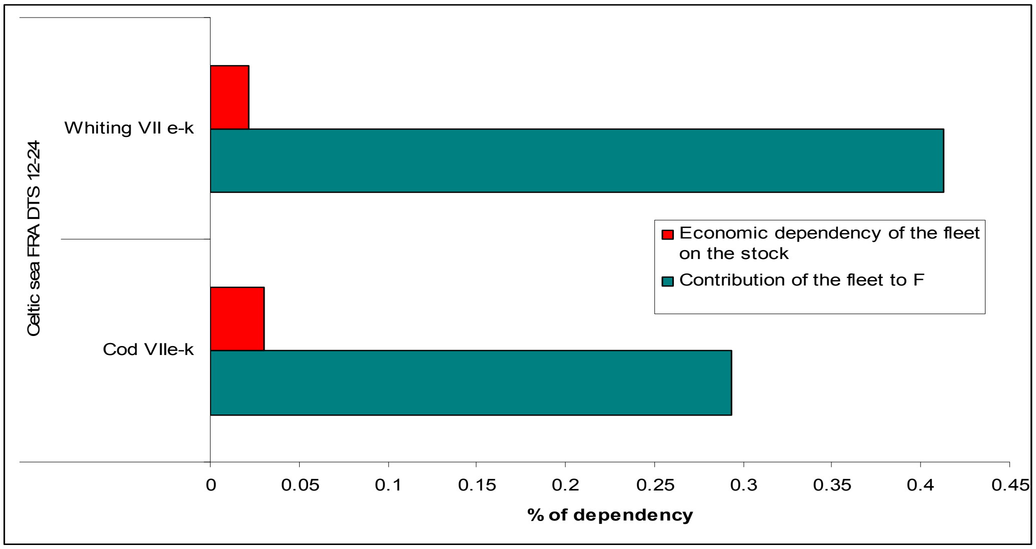
The segment has also harvested outside the Celtic Sea, which is included in this landings. The whiting and cod landings are not specified for area 27.7e-k, but not for the rest of the area. The share is therefore probably too high.

Table 47. To have an idea of total impact on the ecosystem of the respective fleet, we have estimated the shares that respective catch specified in Celtic Sea has on total harvest of this the fleet in all areas.

Celtic sea FRA DTS 12-24 2007

SPECIES	M€		tonnes	
Anglerfishes	30.50	12%	5846.88	8%
Norway lobster	20.38	8%	2110.39	3%
Inshore squids	11.79	5%	1790.90	2%
Cuttlefish	9.72	4%	4673.27	6%
Cod	7.91	3%	2088.90	3%
Surmullet	7.62	3%	2054.86	3%
Raja rays	6.70	3%	2841.50	4%
John dory	6.39	2%	590.74	1%
Whiting	5.70	2%	3135.24	4%
Other	**51.31**	**20%**	**25294.459**	**33%**
CS	**158.01**	**60%**	**50427.137**	**66%**
TOT	**261.85**	**100%**	**75855.370**	**100%**

Figure 20. Economic dependency of the fleet segment on the main stocks and the ecosystem and contribution of the fleet segment to the species F in the ecosystem



ICES Area: Celtic Sea (VIIe-k)
Country: FRA
Gear: DRB
Length: 12-24

The economic dependency of this on the Celtic Sea segment is 100% as the main harvest of this segment dredges (DRB) in 2007.

Table 48 Catch, value and effort for the fleet in the CS. *Source AER, 2009*

FLEET SEGMENT	NUMBER OF VESSELS	VALUE OF LANDINGS (M€)	DIRECT SUBSIDIES (million)	INCOME (million)	AVERAGE WAGE	GVA (million)	OCF (million)	PROFIT / LOSS (million)	INVESTMENTS (million)
DRB VL1218	98	40.4	0.7	41.0	32,973	19.4	4.5	0.1	2.6
DRB VL1824	7	0.0	0.1	0.1	0	0.0	0.1	0.1	0.0

The main species of this segment are SCE, MYV, SOL, CTL and VEV. They constitute a total of 86% of 29.8 mill Euro in 2007.

Table 49 Catch and economic dependency on the main target stocks.

Celtic Sea FRA DRB 12-24

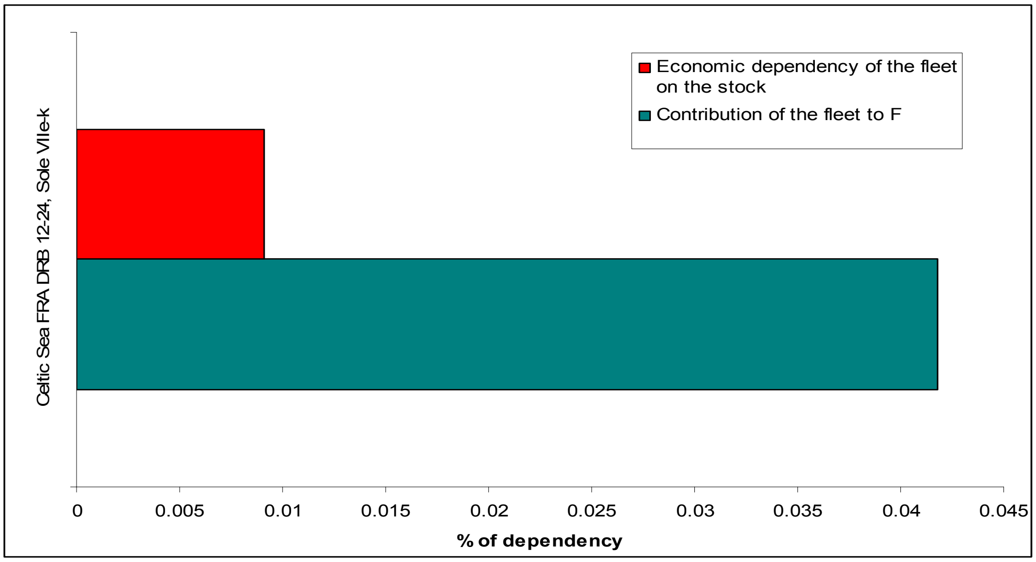
SPECIES*	(M€)	tonnes	Total landings (tonnes)	Share
Great Atlantic scallop	21.41	7959.92	NA	
Mytilidae	1.78	1894.68	NA	
Sole	1.35	129.05	2037	6%
Cuttlefish	0.93	501.59	NA	
Warty venus	0.58	125.76	NA	

Table 50. To have an idea of total impact on the ecosystem of the respective fleet, we have estimated the shares that respective catch specified in Celtic Sea has on total harvest of this the fleet in all areas.

Celtic Sea FRA DRB 12-24

SPECIES	(M€)		tonnes	
Great Atlantic scallop	21.41	72%	7959.918	56%
Mytilidae	1.78	6%	1894.675	13%
Sole	1.35	5%	129.045	1%
Cuttlefish	0.93	3%	501.585	4%
Warty venus	0.58	2%	125.758	1%
Other	**3.70**	**12%**	**3537.364**	**25%**
CS	**29.76**	**100%**	**14148.345**	**100%**
TOT	**29.83**	**100%**	**14177.774**	**100%**

Figure 21. Economic dependency of the fleet segment on the main stocks and the ecosystem and contribution of the fleet segment to the species F in the ecosystem



Economic dependency of the fleet on the stock
Contribution of the fleet to F
Celtic Sea FRA DRB 12-24, Sole VIIe-k
0
0.005
0.01
0.015
0.02
0.025
0.03
0.035
0.04
0.045
% of dependency

APPENDIX 7 - ECONOMIC PERFORMANCE FLEET BY FLEET IN THE NORTH SEA

ICES Area: North Sea (IIIa, IVa-c, VIId)
Country: BEL
Gear: TBB
Length: 2440

Table 7.1 - Belgian beam trawlers 24-40m key indicators in 2008

Fleet segment	Number of vessels	FTE (Or total employed)	Days at Sea (1000 days)	Volume of landings (1000 tons)	Value of landings (million Euros)	Direct subsidies (million Euros)	Total Income (million Euros)	Average wage per FTE (Euros)	GVA (million Euros)	Operating cash flow (million Euros)	Profit / loss (million Euros)	Capital Value (million Euros)	ROI (%)	Investments (million Euros)
BEL TBB VL2440	47	245.0	9.6	14.4	54.6	0.9	57	67.4	15.7	0				2.2

Source: AER 2009

Belgian beam trawlers 24-40m consisted of 47 vessels in 2008. In the same year, the value of landings for this fleet segment amounted to 54.6 million Euros. This fleet segment operates in different areas. The gross revenue realized by this fleet segment in the NS amounts to 36.2 million Euro, 66% of its total revenues. Therefore, the level of dependency of this fleet segment by the NS can be estimated in 66%.

In this case, economic data of the whole fleet can not be used as a proxy to describe the economic performance of the fleet operating in the NS.

In 2008, the main stocks landed in the NS were Sole (SOL) and Plaice (PLE). These two stocks in the NS represent 40% of the total revenues of the fleet segment.

Table 7.2 - Main NS stocks for the Belgian beam trawl 24-40m fleet in weight and value

NS stock	Tonnes	%	MEuro	%
SOL	1599	11%	15.3	28%
PLE	3683	26%	6.7	12%
LEM	567	4%	2.4	4%
COD	700	5%	2.2	4%
TUR	176	1%	2.0	4%
BLL	171	1%	1.4	2%
Other	3401	24%	6.1	11%
Total NS	10297	71%	36.2	66%
Total	14420	100%	54.6	100%

ICES Area: North Sea (IIIa, IVa-c, VIId)
Country: DNK
Gear: TM
Length: 2440

Table 7.3 - Danish Pelagic trawlers 24-40m key indicators in 2008

Fleet segment	Number of vessels	FTE (Or total employed)	Days at Sea (1000 days)	Volume of landings (1000 tons)	Value of landings (million Euros)	Direct subsidies (million Euros)	Total Income (million Euros)	Average wage per FTE (Euros)	GVA (million Euros)	Operating cash flow (million Euros)	Profit / loss (million Euros)	Capital Value (million Euros)	ROI (%)	Investments (million Euros)
DNK TM VL2440	51	248.0	9917	127.4	53.9	140.9	55.3	55.7	25.3	11.6	-3.6	85.8	-0.04	2.5

Source: AER 2009

Danish Pelagic trawlers 24-40m consisted of 51 vessels in 2008. In the same year, the value of landings for this fleet segment amounted to 53.9 million Euros. This fleet segment operates in different areas. The gross revenue realized by this fleet segment in the NS amounts to 37.4 million Euro, 69% of its total revenues. Therefore, the level of dependency of this fleet segment by the NS can be estimated in 69%.

In this case, economic data of the whole fleet can not be used as a proxy to describe the economic performance of the fleet operating in the NS.

In 2008, the main stocks landed in the NS were Sandeel (SAN) and Nephrops (NEP). These two stocks in the NS represent 27% of the total revenues of the fleet segment.

Table 7.4 - Main NS stocks for the Danish Pelagic trawlers 24-40m fleet in weight and value

NS stock	Tons	%	mEuro	%
SAN	61586	48%	7.4	14%
NEP	839	1%	6.9	13%
MON	991	1%	4.2	8%
POK	3902	3%	3.6	7%
SPR	20994	16%	3.1	6%
COD	932	1%	2.9	5%
Other	9975	8%	9.3	17%
Total NS	99219	78%	37.4	69%
Total	127435	100%	53.9	100%

ICES Area: North Sea (IIIa, IVa-c, VIId)
Country: DNK
Gear: TM
Length: 40XX

Table 7.5 - Danish pelagic trawlers over 40m key indicators in 2008

Fleet segment	Number of vessels	FTE (Or total employed)	Days at Sea (1000 days)	Volume of landings (1000 tons)	Value of landings (million Euros)	Direct subsidies (million Euros)	Total Income (million Euros)	Average wage per FTE (Euros)	GVA (million Euros)	Operating cash flow (million Euros)	Profit / loss (million Euros)	Capital Value (million Euros)	ROI (%)	Investments (million Euros)
DNK TM VL40XX	32	216.0	5501	405.3	107.1	0	108.9	101	70.4	48.6	1.3	404.7	0.01	21.1

Source: AER 2009

Danish pelagic trawlers over 40m consisted of 32 vessels in 2008. In the same year, the value of landings for this fleet segment amounted to 107.1 million Euros. This fleet segment operates in different areas. The gross revenue realized by this fleet segment in the NS amounts to 82.2 million Euro, 77% of its total revenues. Therefore, the level of dependency of this fleet segment by the NS can be estimated in 77%.

In this case, economic data of the whole fleet can be used as a proxy to describe the economic performance of the fleet operating in the NS.

In 2008, the main stocks landed in the NS were Mackerel (MAC), Sandeel (SAN) and Herring (HER). These three stocks in the NS represent 67% of the total revenues of the fleet segment.

Table 7.6 - Main NS stocks for the Danish pelagic trawlers over 40m fleet in weight and value

NS stock	Tons	%	mEuro	%
MAC	26033	6%	34.0	32%
SAN	171605	42%	20.9	20%
HER	40562	10%	15.6	15%
SPR	38624	10%	5.9	6%
NOP	26099	6%	3.8	4%
PLE	611	0%	1.2	1%
Other	1250	0%	0.8	1%
Total NS	304784	75%	82.2	77%
Total	405268	100%	107.1	100%

ICES Area: North Sea (IIIa, IVa-c, VIId)
Country: GBR
Gear: DTS
Length: 1824

Table 7.7 – UK demersal trawlers and seiners 18-24m key indicators in 2008

Fleet segment	Number of vessels	FTE (Or total employed)	Days at Sea (1000 days)	Volume of landings (1000 tons)	Value of landings (million Euros)	Direct subsidies (million Euros)	Total Income (million Euros)	Average wage per FTE (Euros)	GVA (million Euros)	Operating cash flow (million Euros)	Profit / loss (million Euros)	Capital Value (million Euros)	ROI (%)	Investments (million Euros)
GBR DTS VL1824	223	1102.8	40.2	50.2	107	5.7	120.6	25482	42.5	20.1	11.8	181.4	0.1	9.5

Source: AER 2009

UK demersal trawlers and seiners 18-24m consisted of 223 vessels in 2008. In the same year, the value of landings for this fleet segment amounted to 107 million Euros. This fleet segment operates in different areas. The gross revenue realized by this fleet segment in the NS amounts to 89.1 million Euro, 83% of its total revenues. Therefore, the level of dependency of this fleet segment by the NS can be estimated in 83%.

In this case, economic data of the whole fleet can be used as a proxy to describe the economic performance of the fleet operating in the NS.

In 2008, the main stocks landed in the NS were Nephrops (NEP), Anglerfish (ANF) and Haddock (HAD). These three stocks in the NS represent almost 60% of the total revenues of the fleet segment.

Table 7.8 - Main NS stocks for the UK demersal trawlers and seiners 18-24m fleet in weight and value

NS stock	Tons	%	mEuro	%
NEP	11226	22%	39.4	37%
ANF	3726	7%	12.9	12%
HAD	9048	18%	10.8	10%
COD	2816	6%	7.1	7%
WHG	4443	9%	5.2	5%
LEZ	859	2%	3.0	3%
Other	6682	13%	10.6	10%
Total NS	38798	77%	89.1	83%
Total	50244	100%	107.0	100%

ICES Area: North Sea (IIIa, IVa-c, VIId)
Country: GBR
Gear: DTS
Length: 2440

Table 7.9 - UK demersal trawlers and seiners 24-40m key indicators in 2008

Fleet segment	Number of vessels	FTE (Or total employed)	Days at Sea (1000 days)	Volume of landings (1000 tons)	Value of landings (million Euros)	Direct subsidies (million Euros)	Total Income (million Euros)	Average wage per FTE (Euros)	GVA (million Euros)	Operating cash flow (million Euros)	Profit / loss (million Euros)	Capital Value (million Euros)	ROI (%)	Investments (million Euros)
GBR DTS VL2440	109	715.3	22.3	58.9	105	6	120.7	37466	37.9	17.1	10.2	155.2	0.1	7.4

Source: AER 2009

UK demersal trawlers and seiners 24-40m consisted of 109 vessels in 2008. In the same year, the value of landings for this fleet segment amounted to 105 million Euros. This fleet segment operates in different areas. The gross revenue realized by this fleet segment in the NS amounts to 82.4 million Euro, 79% of its total revenues. Therefore, the level of dependency of this fleet segment by the NS can be estimated in 79%.

In this case, economic data of the whole fleet can be used as a proxy to describe the economic performance of the fleet operating in the NS.

In 2008, the main stocks landed in the NS were Haddock (HAD), Anglerfish (ANF) and Cod (COD). These three stocks in the NS represent 45% of the total revenues of the fleet segment.

Table 7.10 - Main NS stocks for the UK demersal trawlers and seiners 24-40m fleet in weight and value

NS stock	Tons	%	mEuro	%
HAD	16092	27%	23.9	23%
ANF	3433	6%	12.0	11%
COD	4195	7%	11.4	11%
NEP	1982	3%	7.2	7%
WHG	4390	7%	6.0	6%
POK	6256	11%	4.6	4%
Other	7635	13%	17.3	16%
Total NS	43982	75%	82.4	79%
Total	58863	100%	105.0	100%

ICES Area: North Sea (IIIa, IVa-c, VIId)
Country: GBR
Gear: FPO
Length: 0010

Table 7.11 – UK fleet of vessels using pots and/or traps under 10m key indicators in 2008

Fleet segment	Number of vessels	FTE (Or total employed)	Days at Sea (1000 days)	Volume of landings (1000 tons)	Value of landings (million Euros)	Direct subsidies (million Euros)	Total Income (million Euros)	Average wage per FTE (Euros)	GVA (million Euros)	Operating cash flow (million Euros)	Profit / loss (million Euros)	Capital Value (million Euros)	ROI (%)	Investments (million Euros)
GBR FPO VL0010	1926	1183.9	277.4	21.4	62.7	1.6	70.6	15289	46.7	30.2	8.9	111.6	0.1	0.6

Source: AER 2009

UK fleet of vessels using pots and/or traps under 10m consisted of 1926 vessels in 2008. In the same year, the value of landings for this fleet segment amounted to 21.4 million Euros. This fleet segment operates in different areas. The gross revenue realized by this fleet segment in the NS amounts to 29.8 million Euro, 48% of its total revenues. Therefore, the level of dependency of this fleet segment by the NS can be estimated in 48%.

In this case, economic data of the whole fleet can not be used as a proxy to describe the economic performance of the fleet operating in the NS.

In 2008, the main stocks landed in the NS were Lobster (LBE) and Crab (CRE). These two stocks in the NS represent 37% of the total revenues of the fleet segment.

Table 7.12 - Main NS stocks for the UK fleet of vessels using pots and/or traps under 10m fleet in weight and value

NS stock	Tons	%	mEuro	%
LBE	1121	5%	17.3	28%
CRE	3597	17%	5.6	9%
LIO	1441	7%	3.5	6%
WHE	1976	9%	1.5	2%
COD	139	1%	0.3	0%
SOL	30	0%	0.2	0%
Other	777	4%	1.4	2%
Total NS	9079	42%	29.8	48%
Total	21376	100%	62.7	100%

ICES Area: North Sea (IIIa, IVa-c, VIId)
Country: GBR
Gear: PS
Length: 40XX

Table 7.13 – UK purse seiners over 40m key indicators in 2008

Fleet segment	Number of vessels	FTE (Or total employed)	Days at Sea (1000 days)	Volume of landings (1000 tons)	Value of landings (million Euros)	Direct subsidies (million Euros)	Total Income (million Euros)	Average wage per FTE (Euros)	GVA (million Euros)	Operating cash flow (million Euros)	Profit / loss (million Euros)	Capital Value (million Euros)	ROI (%)	Investments (million Euros)
GBR PS VL40XX	29	125.3	2.1	261.6	152	5.6	159.3	273032	92	63.4	30.7	585.9	0.1	6.8

Source: AER 2009

UK purse seiners over 40m consisted of 29 vessels in 2008. In the same year, the value of landings for this fleet segment amounted to 152 million Euros. This fleet segment operates in different areas. The gross revenue realized by this fleet segment in the NS amounts to 66.4 million Euro, 44% of its total revenues. Therefore, the level of dependency of this fleet segment by the NS can be estimated in 44%.

In this case, economic data of the whole fleet can not be used as a proxy to describe the economic performance of the fleet operating in the NS.

In 2008, the main stocks landed in the NS were Mackarel (MAC) and Herring (HER). These two stocks in the NS represent 43% of the total revenues of the fleet segment.

Table 7.14 - Main NS stocks for the UK purse seiners over 40m fleet in weight and value

NS stock	Tons	%	mEuro	%
MAC	41519	16%	53.0	35%
HER	27347	10%	12.2	8%
JAX	3345	1%	1.2	1%
BRB	33	0%	0.0	0%
PIL	12	0%	0.0	0%
PEL	4	0%	0.0	0%
Other	1	0%	0.0	0%
Total NS	72261	28%	66.4	44%
Total	261625	100%	152.0	100%

ICES Area: North Sea (IIIa, IVa-c, VIId)
Country: NLD
Gear: TBB
Length: 1824

Table 7.15- Netherland beam trawlers 18-24m key indicators in 2008

Fleet segment	Number of vessels	FTE (Or total employed)	Days at Sea (1000 days)	Volume of landings (1000 tons)	Value of landings (million Euros)	Direct subsidies (million Euros)	Total Income (million Euros)	Average wage per FTE (Euros)	GVA (million Euros)	Operating cash flow (million Euros)	Profit / loss (million Euros)	Capital Value (million Euros)	ROI (%)	Investments (million Euros)
NLD TBB VL1824	164	477.5	19	17.4	62.3	0	63.5	36659	30.6	14.3	2.8	81.7	0.06	3.6

Source: AER 2009

Netherland beam trawlers 18-24m consisted of 164 vessels in 2008. In the same year, the value of landings for this fleet segment amounted to 62.3 million Euros. This fleet segment operates in different areas. The gross revenue realized by this fleet segment in the NS amounts to 58.8 million Euro, 94% of its total revenues. Therefore, the level of dependency of this fleet segment by the NS can be estimated in 94%.

In this case, economic data of the whole fleet can be used as a proxy to describe the economic performance of the fleet operating in the NS.

In 2008, the main stocks landed in the NS were Cranger (CSH) and Sole (SOL). These two stocks in the NS represent 86% of the total revenues of the fleet segment.

Table 7.16 - Main NS stocks for the Netherland beam trawlers 18-24m fleet in weight and value

NS stock	Tons	%	mEuro	%
CSH	13458	77%	46.0	74%
SOL	835	5%	7.7	12%
PLE	752	4%	1.4	2%
TUR	95	1%	0.8	1%
COD	346	2%	0.8	1%
DAB	907	5%	0.8	1%
Other	918	5%	1.2	2%
Total NS	17311	99%	58.8	94%
Total	17417	100%	62.3	100%

ICES Area: North Sea (IIIa, IVa-c, VIId)
Country: NLD
Gear: TBB
Length: 40XX

Table 7.17 - Netherland beam trawlers over 40m key indicators in 2008

Fleet segment	Number of vessels	FTE (Or total employed)	Days at Sea (1000 days)	Volume of landings (1000 tons)	Value of landings (million Euros)	Direct subsidies (million Euros)	Total Income (million Euros)	Average wage per FTE (Euros)	GVA (million Euros)	Operating cash flow (million Euros)	Profit / loss (million Euros)	Capital Value (million Euros)	ROI (%)	Investments (million Euros)
NLD TBB VL40XX	65	468.2	12.1	29.7	125	0	125.3	50988	36.8	13.6	-4.7	223	0	3.8

Source: AER 2009

Netherland beam trawlers over 40m consisted of 65 vessels in 2008. In the same year, the value of landings for this fleet segment amounted to 125 million Euros. This fleet segment operates in different areas. The gross revenue realized by this fleet segment in the NS amounts to 114 million Euro, 91% of its total revenues. Therefore, the level of dependency of this fleet segment by the NS can be estimated in 91%.

In this case, economic data of the whole fleet can be used as a proxy to describe the economic performance of the fleet operating in the NS.

In 2008, the main stocks landed in the NS were Sole (SOL) and Plaice (PLE). These two stocks in the NS represent almost 70% of the total revenues of the fleet segment.

Table 7.18 - Main NS stocks for the Netherland beam trawlers over 40m fleet in weight and value

NS stock	Tons	%	mEuro	%
SOL	6653	22%	63.0	50%
PLE	13682	46%	24.1	19%
TUR	1190	4%	11.3	9%
BLL	471	2%	3.7	3%
DAB	3022	10%	2.4	2%
COD	802	3%	1.9	2%
Other	3661	12%	7.6	6%
Total NS	29482	99%	113.9	91%
Total	29698	100%	125.0	100%

ICES Area: North Sea (IIIa, IVa-c, VIId)
Country: NLD
Gear: TM
Length: 40XX

Table 7.19 - Netherland pelagic trawlers over 40m key indicators in 2008

Fleet segment	Number of vessels	FTE (Or total employed)	Days at Sea (1000 days)	Volume of landings (1000 tons)	Value of landings (million Euros)	Direct subsidies (million Euros)	Total Income (million Euros)	Average wage per FTE (Euros)	GVA (million Euros)	Operating cash flow (million Euros)	Profit / loss (million Euros)	Capital Value (million Euros)	ROI (%)	Investments (million Euros)
NLD TM VL40XX	13	508.0	3.4	320.4	141.6	0	142.3	0	48.7	12.6	-4.7	229.6	0	1

Source: AER 2009

Netherland pelagic trawlers over 40m consisted of 13 vessels in 2008. In the same year, the value of landings for this fleet segment amounted to 141.6 million Euros. This fleet segment operates in different areas. The gross revenue realized by this fleet segment in the NS amounts to 37.4 million Euro, 26% of its total revenues. Therefore, the level of dependency of this fleet segment by the NS can be estimated in 26%.

In this case, economic data of the whole fleet can not be used as a proxy to describe the economic performance of the fleet operating in the NS.

In 2008, the main stocks landed in the NS were Jack and Horse Mackerels (CJM and JAX). These stocks in the NS represent almost 20% of the total revenues of the fleet segment.

Table 7.20 - Main NS stocks for the Netherland pelagic trawlers over 40m fleet in weight and value

NS stock	Tons	%	mEuro	%
CJM	32910	10%	17.1	12%
JAX	18306	6%	9.5	7%
HER	21965	7%	7.6	5%
MAS	2056	1%	1.3	1%
MAC	1797	1%	1.1	1%
PIL	1222	0%	0.3	0%
Other	512	0%	0.3	0%
Total NS	78769	25%	37.4	26%
Total	320364	100%	141.6	100%

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Abstract

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